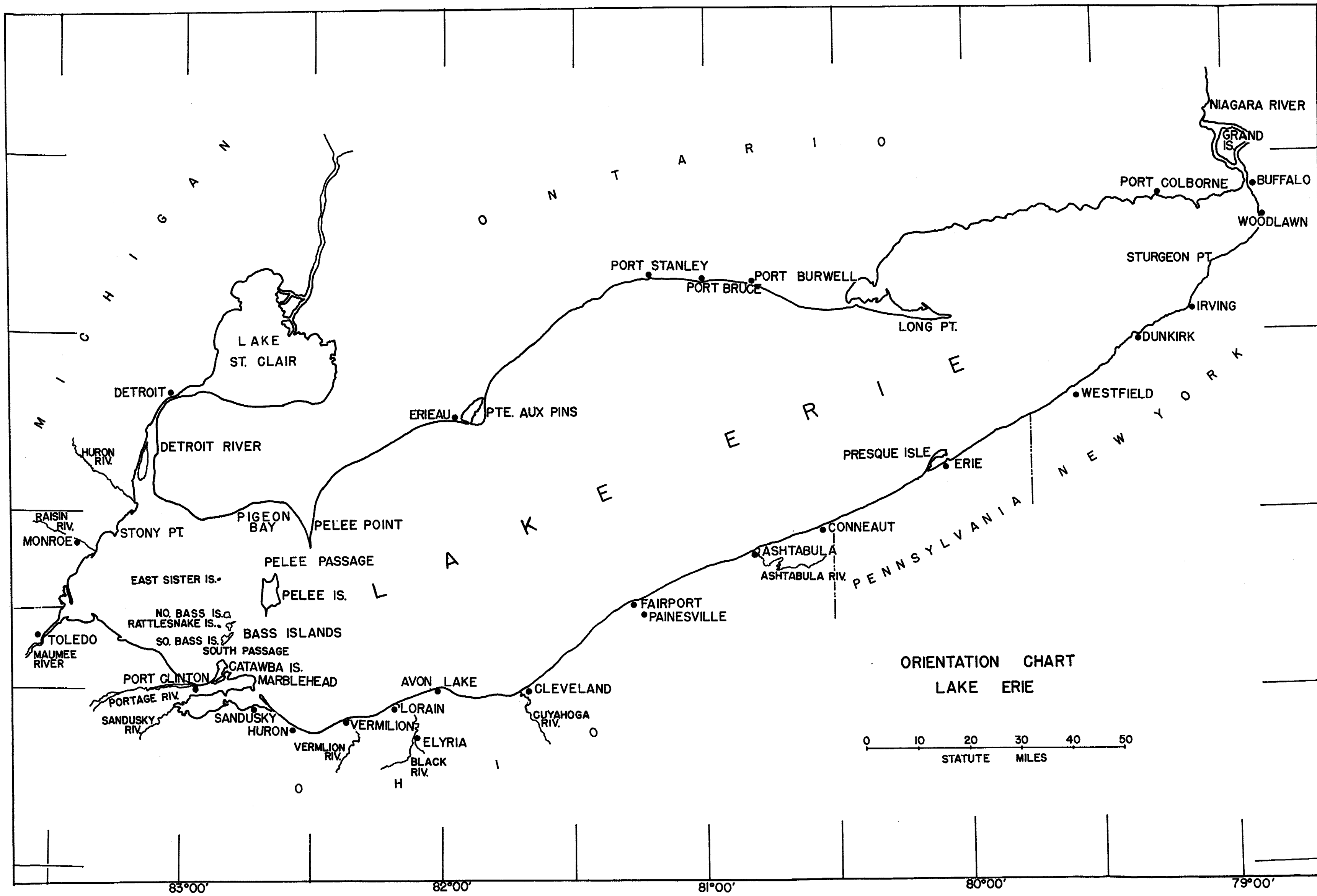

Orientation chart.

GREAT LAKES RESEARCH INSTITUTE
THE UNIVERSITY OF MICHIGAN

EXPLORATION OF COLLATERAL DATA POTENTIALLY APPLICABLE TO GREAT LAKES HYDROGRAPHY AND FISHERIES

Phase II

Final Report

U. S. Fish and Wildlife Service
Contract No. 14-19-008-9381

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TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION AND SUMMARY OF CONTENTS

The present work constitutes the Final Report on Phase II of U. S. Department of Interior, U. S. Fish and Wildlife Service, Contract 14-19-008-9381. Contract 14-19-008-9381 was laid out in three phases. These were:

Phase I. To locate sources and repositories of limnological and meteorological data pertaining to the Great Lakes; to determine the types of data being taken by water plants and other lake-side installations; and to determine the periods of records. This phase was finished in June 1958 and reported by Powers *et al*. 1958.

Phase II. To carry out a pilot study in which data from onshore and near shore sources were tried for compatibility with offshore cruise data; to determine which data sources were most nearly representative of open-lake conditions; to assess methodologies, instrumentations, and other aspects influencing the accuracy and/or representativeness of the data. The present work is the Final Report on this phase.

Phase III. To collect and report those data found to be of maximum usefulness.

The assigned objectives of Phase II have been attained, and in several areas exceeded. The pilot study was carried out on Lake Erie, and consisted of actual application of data from onshore sources to the problem of obtaining a better understanding of the hydrography and aquatic environment.

From the pilot study have come determinations of representative data sources for each of the three basins of the lake. From it has come a new and better concept of the current pattern of Lake Erie. And from it has come, in some cases indirectly, a series of data and techniques by which it is possible to reconstruct several aspects of the environment from the present well back into the nineteenth century.

Among the latter, data and/or techniques for the reconstruction of wind patterns over the lake, rainfall, lake levels, and water chemistry are at hand and ready for application. Partial data are at hand (undoubtedly more can be obtained) for the reconstruction of the regimens of water temperature, air temperature, and weather conditions in and over Lake Erie for periods as long or longer than the extent of fishery records. Except for the partially complete items listed in the sentence above, these data and/or techniques are presented in this report.

A major portion of this report is given to the determination of "representative stations." These are water plants or other water-user installations where data are taken routinely and whose data are representative, in known degrees, of open-lake water. The concept of the representative station as a site or source of data where trends in the condition of the aquatic environment can be conveniently and economically "watched" is not a new one, but it is believed that here for the first time are presented a series of realistically-appraised representative stations for a Great Lake. Once "calibrated" to open-lake conditions as is done here, these stations provide the means for continuous and continuing studies of environmental factors that bear upon fishery problems as well as upon the limnology and hydrography of the lake.

The authors extend their sincere thanks to Prof. D. M. Scott of the Department of Zoology, University of Western Ontario, London, Ontario, for permission to publish the station data of the Fisheries Research Laboratory of the University of Western Ontario. Located at Erieau on Point aux Pins, and receiving financial support from the Research Council of Ontario, this laboratory carried out valuable limnological investigations in west- and north-central Lake Erie in the years 1947-53. These data are given in Appendix II. They have been extremely valuable in our studies and we believe that others will welcome their publication as genuinely as we welcomed the chance to borrow them.

SELECTION OF REPRESENTATIVE STATIONS

One of the primary objectives of Phase II was the selection of shore stations (water filtration plants or other users of Lake Erie water) whose raw water analyses were indicative of conditions obtaining in at least a portion of Lake Erie. The lake is divided naturally into three basins: the west basin, extending to the eastern side of the Bass Islands; the central basin, lying between the Bass Islands on the west and Long Point on the east; and the east basin, between Long Point and Buffalo. A logical beginning to the selection of representative stations seemed to be on the basis of these geographical areas, that is, representative stations might be found for each of the basins.

AVAILABILITY AND ACCURACY OF DATA

Two separate categories of water quality data were needed: data obtained on the raw lake water by the filtration plants, and, for comparison with plant data, observations obtained by some other agency or agencies from the open lake at the same time. The bulk of the information obtained by the plants consists of turbidity, total alkalinity, and bacterial counts, with water temperatures being observed at a few plants. No satisfactory method of utilizing bacteriological data being found, efforts were made to obtain open lake turbidity, alkalinity, and water temperature data. A search of the past history of the lake

revealed a paucity of open lake data, particularly of studies carried out at a particular location over a period of years. A limited body of data representative of open lake conditions, and usable in the selection of representative stations, was eventually assembled. These data are summarized in Table I.

Filtration plants, and other sources of physical-chemical data on raw lake water which could be considered as containing possible representative stations have been tabulated in the Final Report, Phase I, of this project (Powers et al., 1958), along with their periods of record and the data obtained there. Observations upon the raw intake water are made at the filtration plants several times a week. Methodology varies among different plants; total alkalinity is always by titration, usually with methyl orange as the indicator. Turbidity is most generally obtained with the Hellige Turbidimeter, but the Jackson Candle and bottle standards are also in use. Visits were made by the investigators to most of the Lake Erie plants. In all cases the operators, superintendents, and chemists were impressive in their general attitudes, methods, and awareness of responsibility. It is believed that consistency of results may safely be assumed within individual plants; studies to date indicate, at worst, small systematic differences among plants which might be expected when one considers the inherent differences among methodologies and individual observers.

Records for the filtration plants are maintained in reduced form, indicating for each month the average (and usually the maximum and minimum) value for any measured parameter. In Michigan and Ohio, these records are on file with the state departments of health. Data for Erie, Pennsylvania, and Woodlawn, New York, were obtained from the plants. Daily records are usually available for only a few years back, their further accumulation being burdensome and storage impractical.

A lack of raw water data from Canadian filtration plants utilizing Lake Erie water restricted the search for representative stations almost entirely to the south shore of the lake.

The selection of representative stations was a two-fold operation depending, first, upon a determination of the average surface current pattern (which would indicate those stations where offshore water came to shore) and, second, upon simultaneous shore station and open lake physical-chemical data that could be compared to give definitive assessments of the representativeness of stations apparently sampling water from offshore. Initial efforts, then, were directed at the determination of the average surface current pattern existing under the prevailing southwesterly wind. This pattern would be the one expected to occur the majority of the time.

SURFACE CIRCULATION OF LAKE ERIE

Although complete synoptic coverage of Lake Erie has never been attempted, sufficient data from a number of sources now exist to permit the synthesis of a

TABLE I

SUMMARY OF OPEN-LAKE PHYSICAL-CHEMICAL DATA USABLE IN THE SELECTION OF REPRESENTATIVE ONSHORE STATIONS

Source	Years and Region	Applicable Data
Buffalo Museum "Shearwater" cruises[1]	1928: east basin 1929: east and central basins	methyl orange, phenolphthalein, total alkalinity; turbidity; water temperature; wind speed and direction
D. C. Chandler, University of Michigan[2]	1938-45: Bass Islands	methyl orange, phenolphthalein, total alkalinity; turbidity; water temperature
D. M. Scott, University of Western Ontario, London[3]	1947-53: central basin	methyl orange, phenolphthalein, total alkalinity; water temperature
U. S. Fish and Wildlife Service, Ann Arbor, Michigan[4]	1958: west basin, plus drift bottle returns from central and east basins	total alkalinity, turbidity, silica, magnesium, sodium, water temperature, wind speed and direction

[1] 1928 Data published (Parmenter, 1929).
1929 Unpublished data of C. J. Fish, Narragansett Marine Laboratory, University of Rhode Island.
[2] Data published in part: Chandler (1940, 1942, 1942-a, 1944); Chandler and Weeks (1945).
[3] Data published here (Appendix II).
[4] Data published in part: U. S. Fish and Wildlife Service Cruise Reports (1958).

composite pattern of surface circulation. The pattern as derived appears to be generally representative of the surface currents existent under the normal regimen of prevailing southwest winds.

The data sources utilized in the present synthesis, together with the specific portions of the lake which they represent, are as follows:

1. West end: Ayers (unpublished), Harrington (1894), Millar (1952), Olson (1951), U. S. Fish and Wildlife Service (1958), Verber (1955), Wright and Tidd (1955).

2. Bass Islands to Dunkirk: Buffalo Museum 1929 cruises (unpublished), Harrington (1894), U. S. Fish and Wildlife Service (1958).

3. Dunkirk to Buffalo: Harrington (1894), Parmenter (1929), U. S. Fish and Wildlife Service (1958), Fall (1910), McLaughlin (1911).

Of the Buffalo Museum 1929 cruises, Cruise 2, made in June 1929, is the only one applicable to the synthesis of a current pattern. Between the Bass Islands and Dunkirk most of the stations were occupied under winds from westerly quarters; exceptions were stations 43-46 (wind S-zero to calm) and stations 32-37 (wind calm to SE-2). Between Dunkirk and Buffalo winds were from easterly quarters, hence data of Cruise 2 from that area have not been utilized here.

Data from the several remaining cruises made by the Buffalo Museum in the summer of 1929 were not suitable for incorporation into an analysis of the circulation, due to the variable winds encountered during each cruise.

Observations of temperature from Cruise 2 have been used in the computation of dynamic heights over that portion of the lake between Cleveland and Dunkirk. Although temperatures at each station were obtained at only surface, ten meters, and bottom, the lack of thermal stratification in early June lends validity to interpretations of vertical temperature structure based upon these relatively few data. A reference level at only twenty meters was required by the shallowness of the lake, and the assumption of no motion at this depth is probably not altogether realistic. However, the completed dynamic topography appears reasonable and is consistent with other parameters. Plots of turbidity and total alkalinity, as observed during Cruise 2, have been used as supplementary evidences of circulation patterns. Drift bottle returns from releases made by the U. S. Fish and Wildlife Service during 1958 and by Harrington in 1892 and 1893 have been used extensively in checking the computed current pattern between Cleveland and Dunkirk, and in deduction of the circulation pattern in the western and eastern ends of the lake where no dynamic calculations were possible. Other sources, to which reference has already been made, were consulted in the analysis of the west basin circulation. The final current pattern as synthesized from all data is given in Fig. 1.

Description of Data.—The usual description of data is not feasible here, since the results of numerous workers have been used. For the most part, neces-

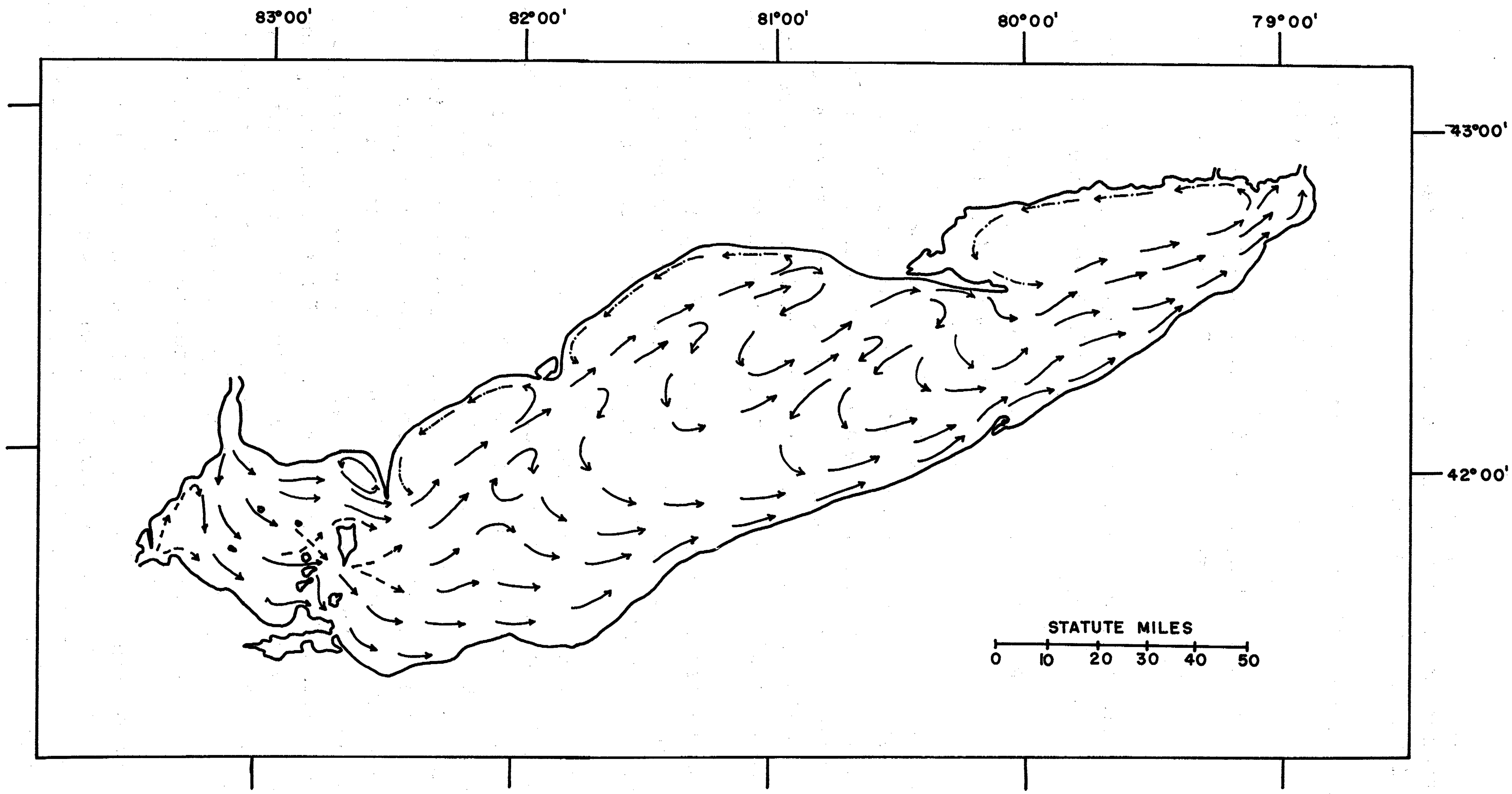

Fig. 1. Composite surface circulation, Lake Erie, under prevailing winds.

sary description is incorporated into the presentation of the deduced composite circulation. However, returns of the Fish and Wildlife Service (hereafter referred to as FWS) drift bottle releases of May and August, 1958, merit special consideration, for certain features of their distributions have particular significance.

In May, bottles released at stations northwest and north of Pelee Island stranded in three regions: on the west side of Pelee Point; between Port Burwell and the tip of Long Point; and on the south shore between Irving, N. Y. and Buffalo. In addition, one bottle was recovered on Grand Island in the Niagara River. Bottles released in the same longitude, but south of the north end of Pelee Island, were recovered on the south shore between Catawba Island and Dunkirk, New York, with a few stranding in the Bass Islands. None of these bottles were recovered from the north shore. A further feature of the south shore recoveries was the concentration of returns between Catawba Island and Fairport, and the virtual absence of returns from Fairport to the Pennsylvania-New York state line. Only one bottle was found (at Erie, Pa.) in this otherwise barren region, although returns were obtained from the New York shore farthest east. Special note should be taken of the fact that bottles released north and south of Pelee Island remained completely separated, except along the New York shoreline where bottles from both areas of release were recovered.

In August, the pattern of returns was quite similar to that of May. The differential north shore-south shore pattern was still present, the primary difference being that the line of demarcation between north-shore-stranding stations and south-shore-stranding stations had shifted to the south. The line now lay slightly south of the southern end of Pelee Island. Bottles from north shore stations were again found at Pelee Point, between Port Burwell and the tip of Long Point, and on the south shore between the Pennsylvania-New York boundary and Buffalo. In addition, bottles were recovered from Point aux Pins, Grand Island, Port Colborne, and between Pelee Point and Point aux Pins. Bottles from all remaining stations in the Bass Islands longitude beached on the south shore, predominantly between Fairport and Conneaut. Absence of returns from a large portion of the south shore, the region between Conneaut and the Pennsylvania-New York line, was again in evidence. Again, only a single bottle (recovered at Erie, Pa.) appeared in this otherwise recoveryless stretch of shoreline. Bottles from two of the south shore stations progressed beyond Conneaut: those from one station off Marblehead beached at Erie and at Sturgeon Point, N. Y.; those from a station just west of Catawba Island beached at the Pennsylvania-New York line, near Port Colborne, Ontario, and on Grand Island.

Recoveries from drift bottle releases made by Harrington in 1892-93 coincide well with those of the 1958 FWS releases. With the exception of one bottle that stranded on the shore of Pigeon Bay (in the west basin), none of his bottles released in the Bass Islands region south of Pelee Island beached on the north shore. Also, the south shore hiatus observed in the FWS returns is evident: only one return was obtained from the shore between Conneaut and Westfield.

Description of the Circulation.—Investigations in the west basin of Lake Erie have indicated the circulation to be complex and variable. In general, under the normally prevailing southwesterly winds, the effluent of the Detroit River (the major source of inflow into Lake Erie) swings through the basin in a counterclockwise loop. This water, identifiable by its comparatively low turbidity, alkalinity, and hardness is commonly observed passing eastward through Pelee Passage. South of Pelee Island increased turbidity, alkalinity, and hardness indicate the presence of admixed quantities of water from the Maumee River and from smaller streams, principally the Huron, Raisin, and Portage rivers. This mixed water ordinarily passes east through the Bass Islands. The boundary separating the unmodified Detroit River water from the mixed water fluctuates in geographic location, being strongly and rapidly influenced by changes in direction of wind.

As indicated by the dynamic heights computed from the Buffalo Museum Cruise 2 (Fig. 2), the outflow from Pelee Passage moves to the northeast toward Point aux Pins and along the lakeward side of a tentative counterclockwise eddy lying in the embayment between Pelee Point and Point aux Pins. This eddy is supported by two FWS bottles, released in August 1958 just southwest of Pelee Point, which stranded halfway between Pelee Point and Point aux Pins, and by the very existence of the two points themselves which could be both built and maintained by such an eddy circulation. Three bottles released near mid-lake by Harrington were recovered on the beach west of Point aux Pins; they likewise point to the existence of this eddy.

The main line of current flow continues northeast past Point aux Pins, toward Port Burwell, and passes along the outside of a counterclockwise eddy lying in the embayment between Point aux Pins and Port Burwell. This eddy, also considered tentative, is confirmed by two FWS bottles released in August 1958 just southwest of North Bass Island and which stranded near Port Bruce; also by two of Harrington's bottles: one from just south of Pelee Point which stranded west of Port Stanley, and one released south-southwest of Port Stanley near mid-lake and recovered at Point aux Pins.

Southeast of Port Burwell the main current impinges on shore in an area marked by concentrated bottle returns from FWS "north shore" stations. This impingement is indicated by the tongue-like extension of the dynamic height contour of 20.011 (Fig. 2), by the area of < 3 ppm turbidity extending northeast to this point (Fig. 3), and by the 102 ppm contour of total alkalinity (Fig. 4). It is also the site of beaching of two of Harrington's bottles which were released north of mid-lake off Point aux Pins.

After impinging on Long Point, the current is indicated by the dynamic computations as turning southwest away from shore, to mid-lake, thence northeast again to Long Point at an area several miles southeast of the initial impingement. The return of the current to this region is substantiated by another concentration of FWS bottles released near mid-lake southwest of Long Point; by the northeast extension of the 3 and 4 ppm contours of turbidity extending from mid-lake (Fig. 3); and by the extension shoreward of a > 102 ppm area of total alkalinity located in mid-lake (Fig. 4).

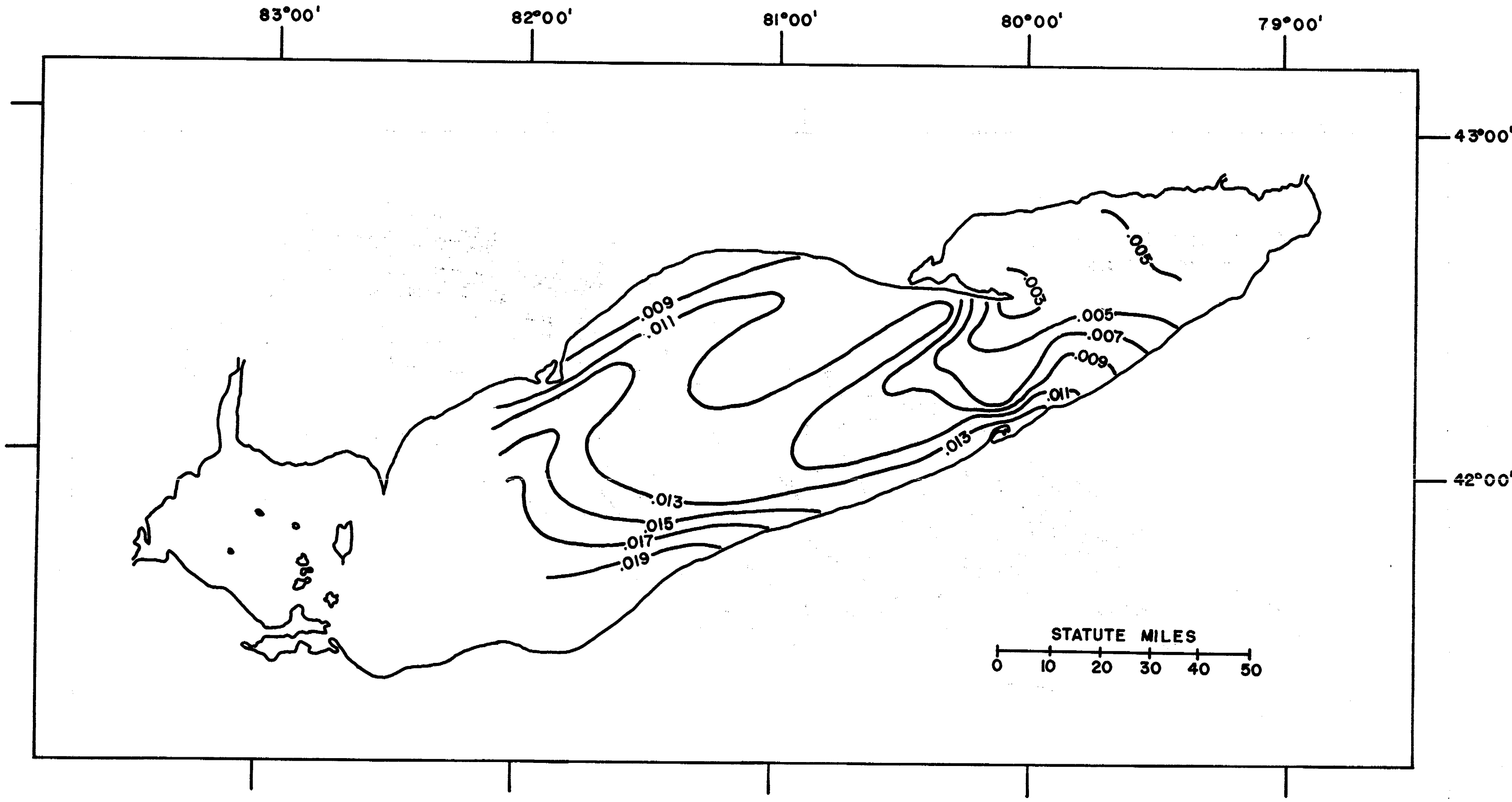

Fig. 2. Dynamic topography of lake surface referred to the 20-decibar level; summer, 1929.

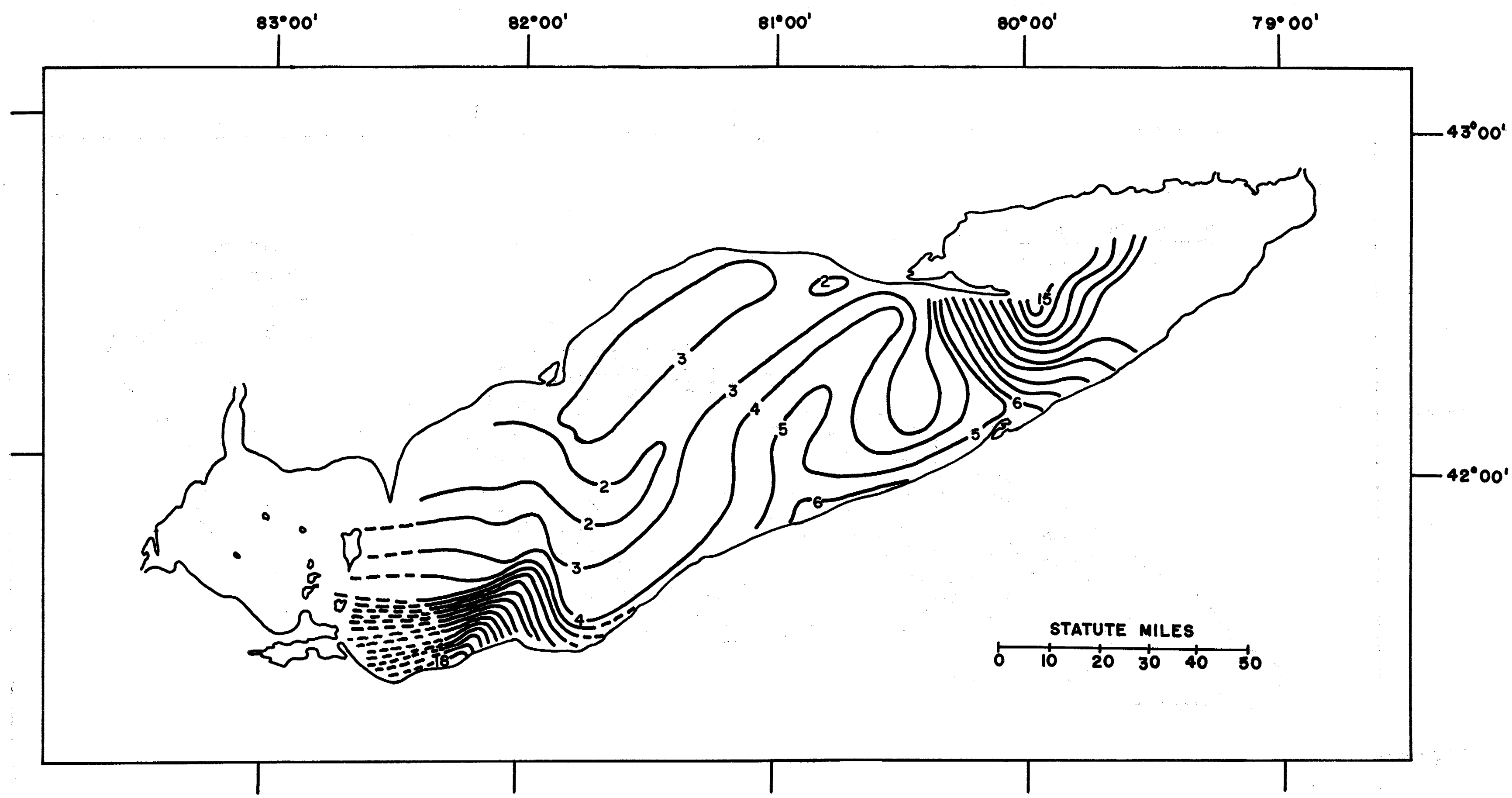

Fig. 3. Surface turbidity, ppm; summer, 1929.

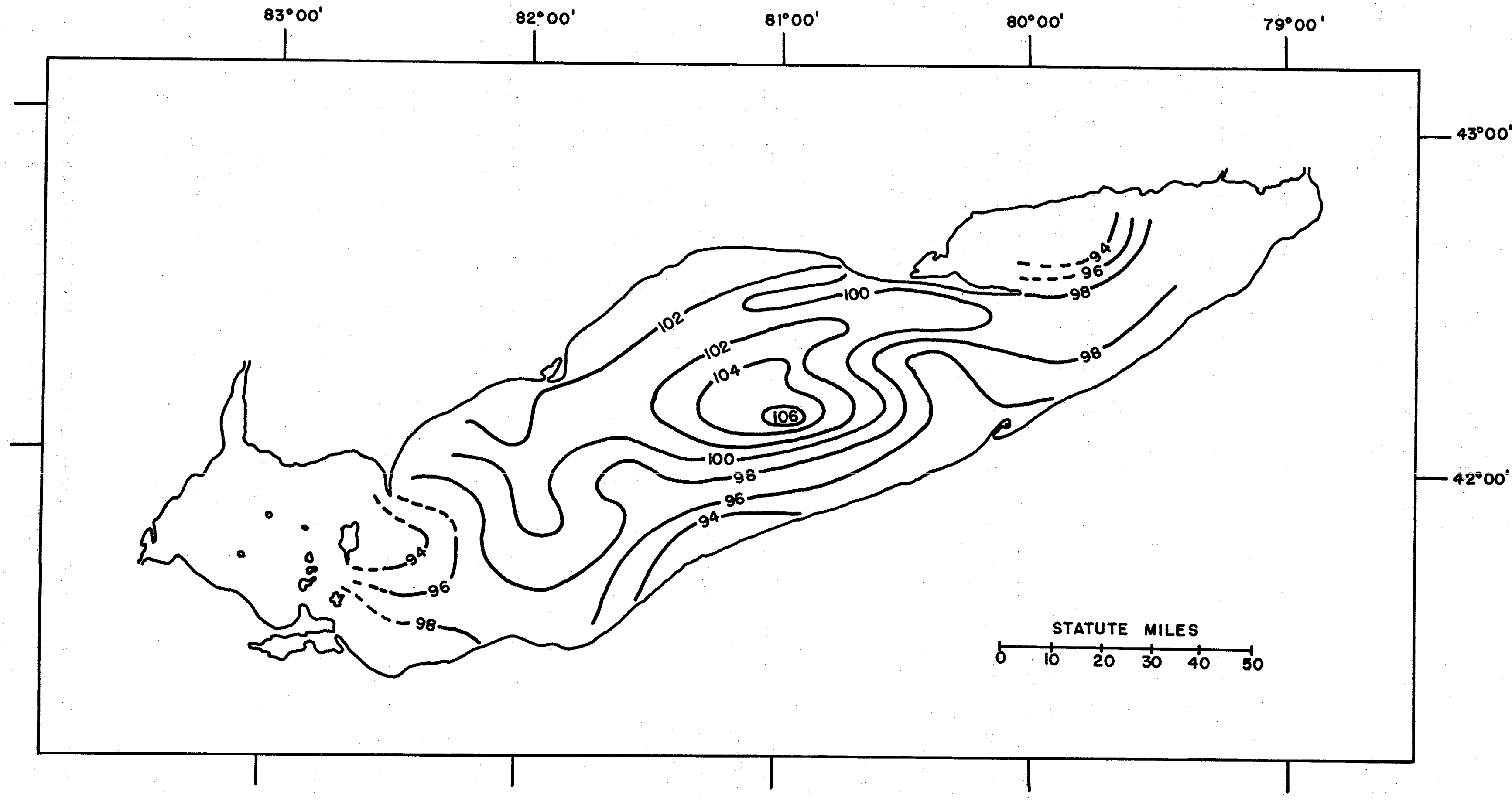

Fig. 4. Surface total alkalinity, ppm; summer, 1929.

After its second impingement on Long Point, the current appears to flow southeast along the Point before once again swinging away from shore, southwestward, to cross the lake. In the region off Ashtabula it encounters an eastward flow along the south shore. The southwestward recurving of the 3 and 4 ppm contours of turbidity (Fig. 3) support the dynamics in indicating this southwest flow.

The southern alongshore current appears to have originated partly as the outflow from the west basin through the Bass Islands, and partly as a southeast offshoot of the main current through Pelee Passage. The dynamic heights (Fig. 2) indicate a southeast current originating south of Point aux Pins, and such a flow is also suggested by the southeast curving of the contours of turbidity (Fig. 3) and total alkalinity (Fig. 4) in that region. Evidence for the alongshore current emanating from the island region is obtained from FWS drift bottle returns from releases at "south shore" stations, where beaching occurred all along shore from Catawba Island to Conneaut; from the lobate gradient of turbidity, with values increasing toward the west, situated off Lorain and Cleveland (Fig. 3), and by the 98 ppm contour of total alkalinity leading from the Bass Islands and beaching near Lorain (Fig. 4). Numerous bottles released by Harrington also were recovered along the south shore, particularly between Cleveland and Conneaut.

The eastward current along the south shore near Erie, Pennsylvania, appears to have the effect of holding offshore the current arriving from the north side of the lake. The dynamic height contours of 20.011, 20.090, and 20.070 dynamic meters extend southwest from Long Point, recurve to parallel the axis of the lake, and then come to shore east of Erie (Fig. 2). The suggestion that this current remains offshore between Conneaut and the vicinity of the Pennsylvania-New York line is substantiated by the lack of drift bottle returns from this section of shore in the results of both Harrington and the FWS. It is also suggested by the shape of the 98 ppm contour of total alkalinity (Fig. 4), and by the 5 ppm contour of turbidity (Fig. 3) which remains offshore to the vicinity of Erie, where it encounters an east-west gradient with isopleths beaching east of Presque Isle.

East of Long Point and Erie the circulation pattern is somewhat conjectural. Data obtained in this region by the Buffalo Museum during the summer of 1928 (Parmenter, 1929) indicate an eastward flow extending from the central axis of the lake to the south shore, continuous to the outlet at the Niagara River. Fall (1910) and McLaughlin (1911) also show the eastern parts of such a flow. Drift bottle returns of Harrington and FWS support the existence of the eastward flow to the outlet. The data also suggest that easterly winds can bring about a reversal of this flow, but the frequency of such a reversal and its effect on the circulation of the central basin cannot be assessed from the information available.

In the embayment to the east of Long Point there is evidence of a counterclockwise eddy. This evidence is furnished by several Harrington's drift bottles which apparently followed courses indicative of a counter (westward) flow along the Canadian shore between Port Colborne and Long Point. Also, two FWS

bottles released in August were recovered at Port Colborne. The northward recurving of the eastward portion of the turbidity gradient located south and southeast of Long Point (Fig. 3), as well as the curvature of the 98 and 94 ppm contours of total alkalinity extending eastward from Long Point (Fig. 4) are suggestive of eddy motion in this area.

REPRESENTATIVE STATIONS FOR THE WEST BASIN

It might be expected that a station representative of open lake conditions in the west basin would be one of those located on the shores of this basin, that is, the filtration plants at Monroe, Toledo, or Port Clinton. None of these plants were usable, however, because each reflects the conditions of a localized water source and not the mixed product of the several sources contributing to the west basin. As has been pointed out, the circulation in this basin is complex and variable. Depending upon the wind, Monroe's intake off Stony Point may sample, predominantly, either Detroit River or Maumee River water and may at times be largely affected by the effluent of the River Raisin which enters the lake at Monroe south of the intake. The Toledo intake, being located near the mouth of the Maumee River, samples proportionately large amounts of water from this source. The Port Clinton intake is located just off the mouth of the Portage River and largely reflects conditions of the river water rather than those of the lake. Knowledge of physical-chemical conditions existing in the Maumee and Portage rivers was obtained from data of the Lake Erie Pollution Survey Supplement (State of Ohio, 1953).

Since the generalized circulation pattern shows the presence of an eastward flow along the south shore of the lake and indicates that this flow might be the mixed effluent from the west basin, it appeared reasonable to continue the search for a station representative of the west basin by using data from filtration plants located on the south shore to the east of the Bass Islands. Such south shore plants are Sandusky, Huron, Vermilion, Elyria, Lorain, Avon Lake, Cleveland, Fairport, Painesville, Ashtabula, and Conneaut.

The Data.—Data obtained by D. C. Chandler in the Bass Islands region were considered to be adequately representative of water conditions in the west basin. These data were obtained between September 1938 and December 1945. A number of parameters were observed, but for purposes of the present investigation turbidity and total alkalinity were the most applicable, they being parameters consistently measured by the filtration plants. Periods and locations of these observations, as obtained by Chandler, are as follows:

(1) Total alkalinity: September 1938 to October 1940, at a single station just off the west side of Rattlesnake Island; January 1943 to December 1945, at four stations located in a north-south direction: one just northeast of East Sister Island, one just west of North Bass Island, one at Rattlesnake Island (identical with the one used in the 1938-40 series), and one in South Passage between Catawba Island and South Bass Island.

(2) Turbidity: January 1941 to December 1945, at the Rattlesnake Island station. (Some previous data also exist, but are not as nearly complete as the 1941-45 data.)

Measurements of total alkalinity and turbidity obtained by Lake Erie filtration plants were available for the same time intervals as those during which Chandler's investigations were conducted. Since the plant data were monthly averages, Chandler's data were likewise reduced: all observations for a given calendar month being averaged to obtain a single monthly mean. Direct comparisons between the onshore and open lake observations could then be attempted. It should be pointed out that Chandler's observations of total alkalinity were obtained once a week, on the average, so that they probably do not present as realistic a mean value as do those from the plants which are based on 20-30 days' observations. On the other hand, the turbidity observations of Chandler were made almost daily, except in mid-winter when fewer data were obtained.

<u>Effect of Intake Location Upon Variability of Data</u>.—Initial examination of the alkalinity data of several of the plants and comparison of these data to those the Ohio Pollution Survey obtained in various bays, harbors, and rivers made possible the immediate elimination of the following plants:

Sandusky — water partially from Sandusky Bay
Huron — water partially from Sandusky Bay
Fairport — local industrial pollution
Painesville — local industrial pollution
Ashtabula — raw water alkalinity not measured

While these studies were going on it was noted that there was an apparent relationship between intake location and variability of observed alkalinity and turbidity. The intake location studies substantiated the elimination of the above plants and also suggested the further elimination of Vermilion, Elyria, Avon Lake, and Conneaut.

To examine the effects of intake location, five plants were chosen whose intakes were located at different distances from shore. The plants and their intake locations are:

Filtration Plant	Intake Distance from Shore (ft)	Intake Depth (ft)
Cleveland (Division Plant), Ohio	21,120	36
Erie, Pennsylvania	6,200	22
Lorain, Ohio	2,000	13
Avon Lake, Ohio	1,400	12
Fairport, Ohio	1,000	12

For these plants, data over the twelve year period 1940-1951 inclusive were arbitrarily chosen as representing average conditions. For each year's data at each plant the lowest monthly average of both turbidity and alkalinity was subtracted from the highest monthly average to obtain the average range for the year. The twelve annual ranges for each plant were then combined to give a twelve years' overall average range for each parameter. These average values were then entered upon graphs in which ranges of turbidity and alkalinity were plotted against distance of intake from shore and against depth of intake.

The turbidity results were quite clear-cut (Fig. 5). Variabilities were about the same at Cleveland and Erie, with Erie showing slightly less variability. This is apparently due to the geographic position of the Cleveland intakes. They are situated where they may be reached by waters of both the western and central basins. The Cleveland variability is most probably caused by alternate sampling of western and central basin waters as shifts in wind direction bring one or the other of these two water types over the intakes. Variability increased sharply at Lorain where the intake is 2,000 feet out, and was still more pronounced at Avon Lake and Fairport whose intakes are 1,400 and 1,000 feet from shore respectively.

Variation of total alkalinity with intake location (Fig. 6) is as clearly defined as was that of turbidity, and the curve is approximately like that for turbidity. Cleveland again has a greater range of variability than does Erie (and the same reason apparently applied). Lorain has a slightly higher variability than does Fairport but the difference, half a part per million, is probably not significant.

The curves relating variability to intake depth approximated the distance-from-shore curves and both showed lessened variability with greater depth and with greater distance from shore. This is to be expected since distance from shore and depth of intake are not mutually-independent variables.

Further evidence of the effect of intake location has come from the data of the Conneaut plant, whose intake was moved further out in 1933. The previous location has not been ascertainable, but it was inshore of the present site. Variability of total alkalinity before and after the change is depicted in Fig. 7. The bars are yearly ranges of alkalinity, based on monthly averages, for the years 1923 through 1942. The stabilizing effect of the intake change is evident. The <u>greatest</u> range occurring after 1933 (26 ppm in 1940) is equal to the <u>least</u> range that occurred in the years prior to the change (26 ppm in 1928).

It seems likely that, of the two variables, distance from shore is the more important. Best correlation of alkalinity and turbidity data from Lorain with those of Chandler from the Bass Islands (discussed later) was obtained in years when rainfall and runoff were normal or below normal, with correlation becoming less good in wet years. If depth of intake were the more important, the reverse situation might have been expected, i.e., better correlation in wet years when lake level might be rising and depths to the intakes increasing. But during 1938-40, when the best correlation was obtained, the lake level was significantly

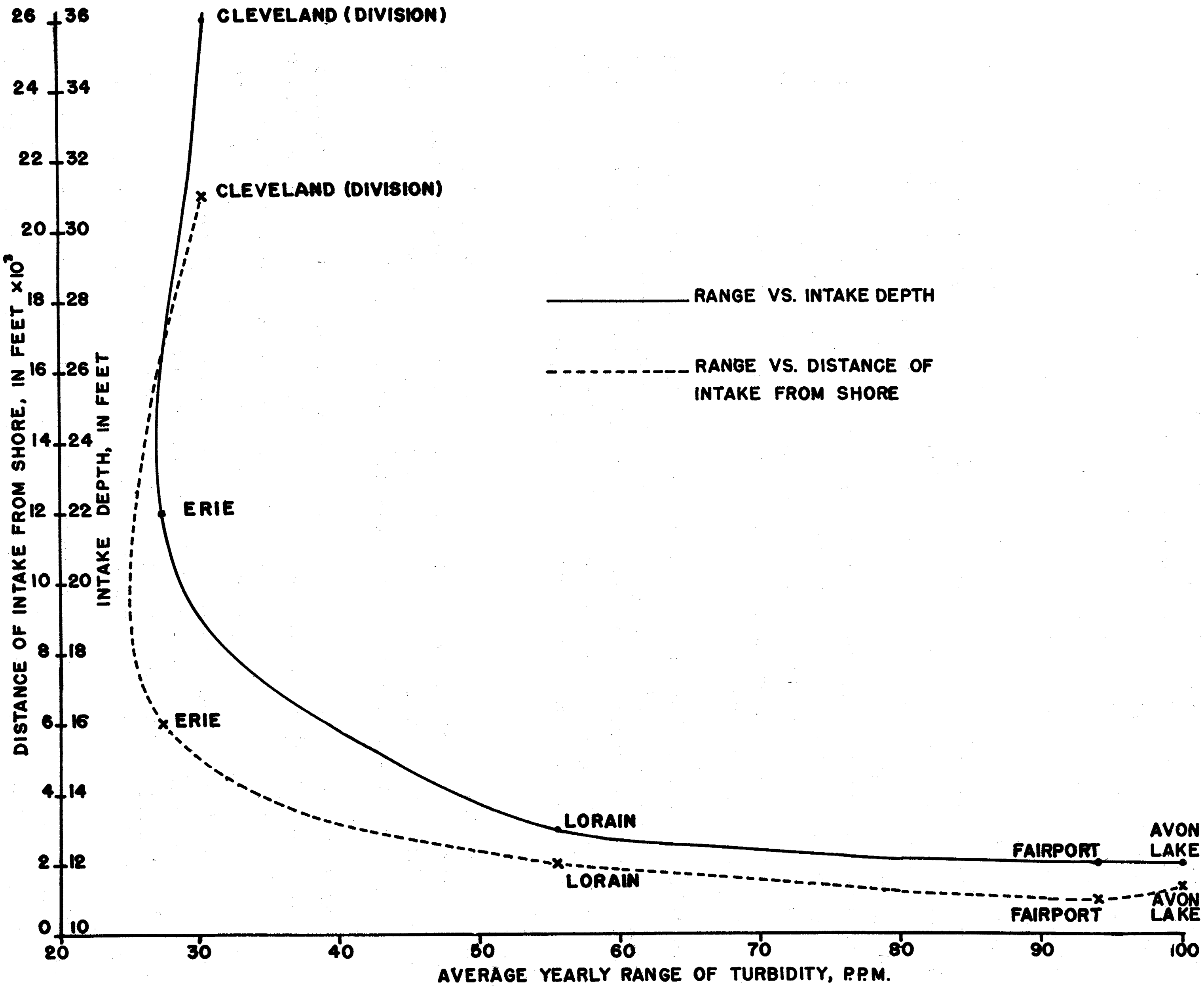

Fig. 5. Average yearly range of turbidity vs. distance from shore and depth of intake, at Cleveland, Erie, Lorain, Fairport, and Avon Lake.

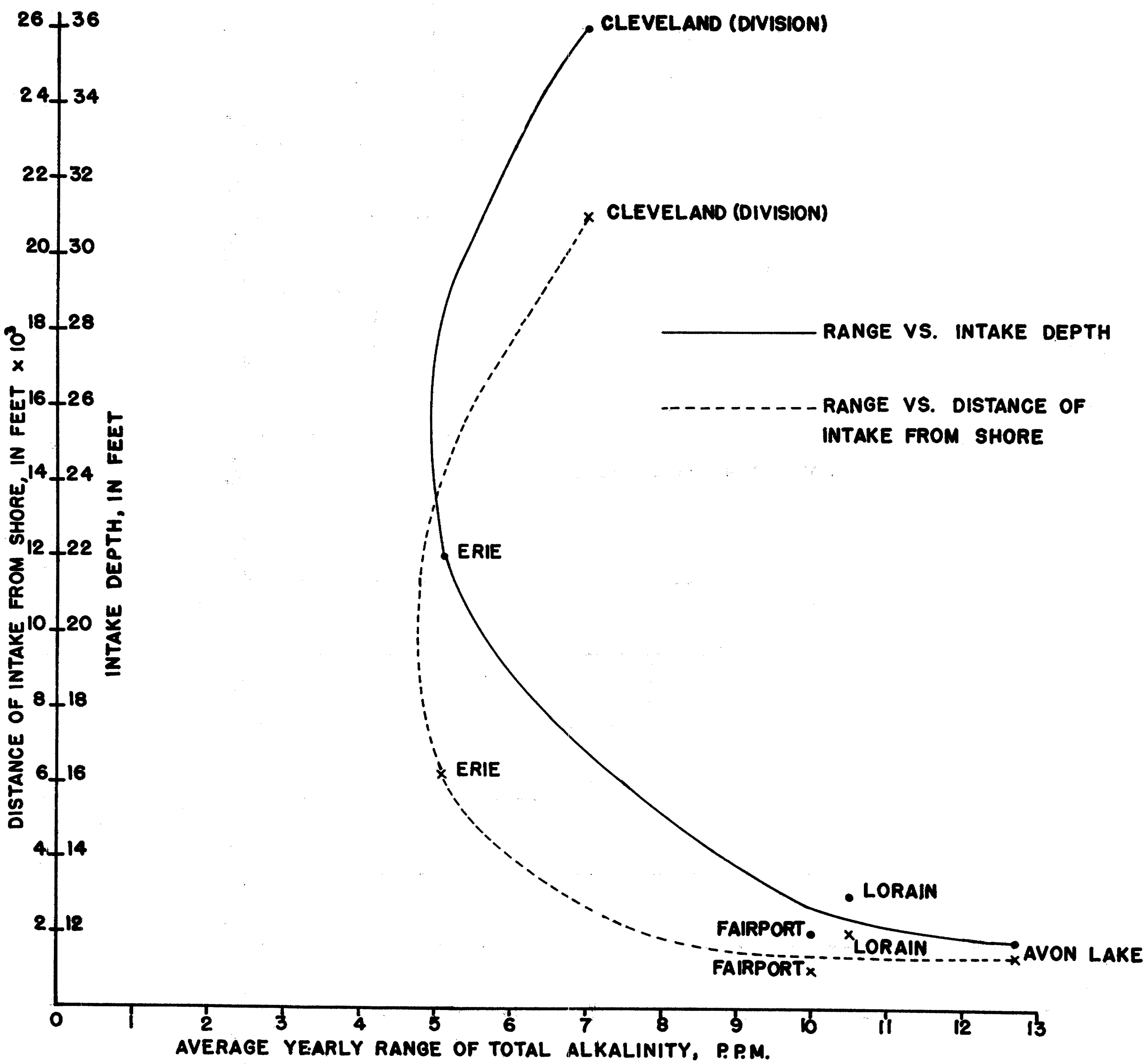

Fig. 6. Average yearly range of total alkalinity vs. distance from shore and depth of intake, at Cleveland, Erie, Lorain, Fairport, and Avon Lake.

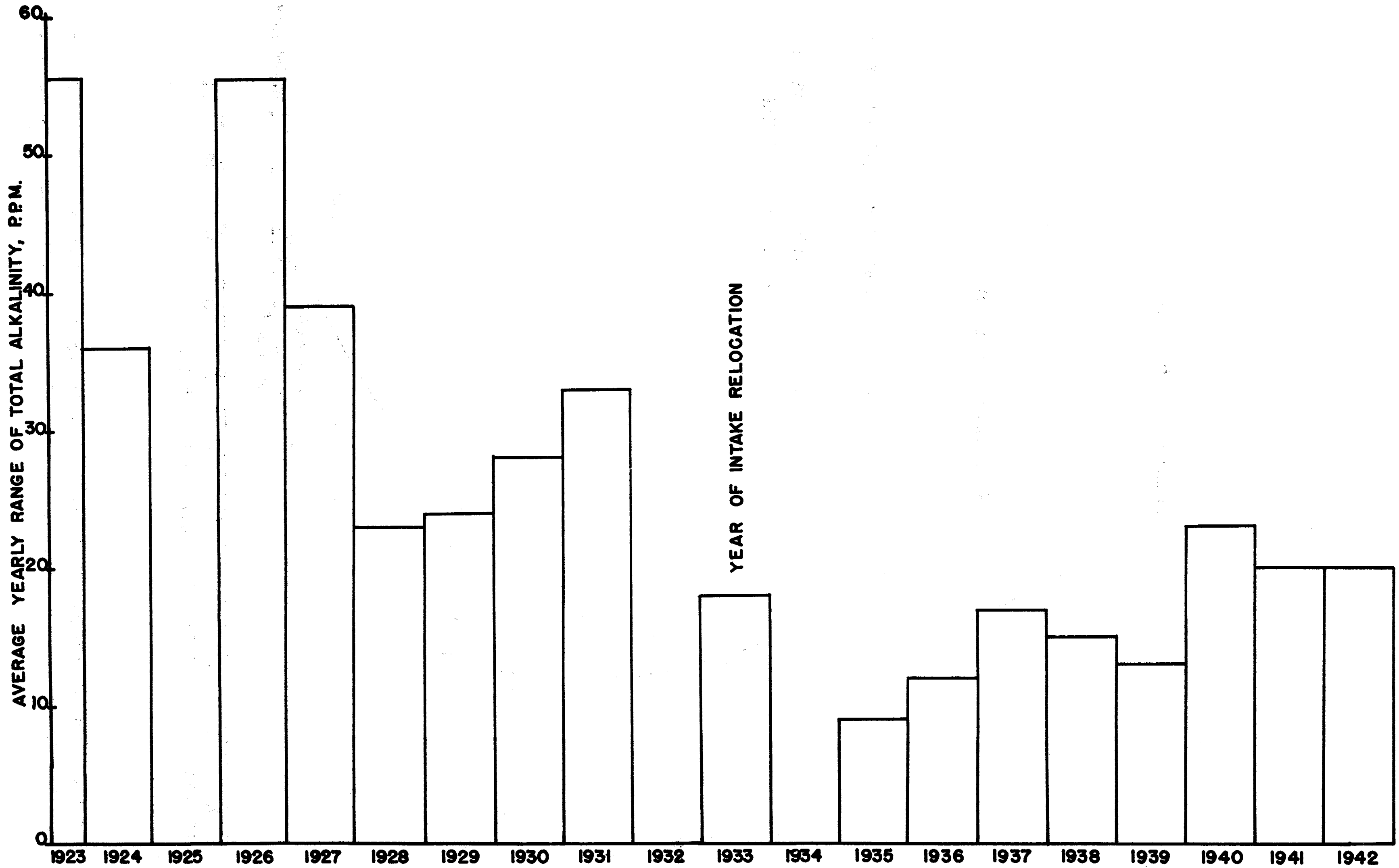

Fig. 7. Average yearly ranges of total alkalinity before and after change of intake location at Conneaut.

lower than in 1943-45 when correlation was less satisfactory.

There appears to be a critical distance, about 2,000-4,000 feet offshore, at which a marked change in variability of parameters occurs. At greater intake lengths, fluctuations are small. At less than this critical range, decreasing distance from shore is accompanied by increasing fluctuation. It appears, also, that increased runoff from tributary streams during wet years serves to increase alongshore variation in the several parameters, and those plants with intakes farthest from shore are least affected. During dry years the plants with short intakes reflect in the decreased variability of their data the decreased alongshore fluctuations that accompany decreased runoffs.

The above must not be taken to imply that depth of intake is unimportant. For drinking-water purposes, it is desirable that the intake be, if possible, below the normal depth of the thermocline. The scanty data presently available (not discussed in this report) indicate that water of materially better quality is to be had from beneath the thermocline. The reason for this appears to be that the density stratification accompanying the thermocline confines to the epilimnion much of the pollution introduced along shore.

Height of intake above bottom appears to be an independent secondary factor that is imposed upon the effect of distance from shore. The two intakes at Cleveland are located the same distance from shore, but that for the Baldwin plant is higher off the bottom than is that of the Division plant. The raw water of the Baldwin plant consistently runs 7 to 17 ppm lower in turbidity and 1 to 2 ppm lower in alkalinity than does that of the Division plant (see Table II). The reason for the differences appears to be that sediments resuspended from the lake bottom by winds or currents have freer access to the lower intake of the Division plant.

<u>Determination of Representativeness</u>.—On the basis of both current pattern and intake location Lorain appeared to possess the greatest likelihood of being a representative station for the west basin, with Cleveland a less strong possibility.

Time graphs were constructed on which monthly average total alkalinities and turbidities for the plants at Lorain, Vermilion, Avon Lake, Cleveland, Conneaut, and Erie were plotted against time. Chandler's Bass Islands data were also entered on this graph.

In the case of total alkalinity, good visual agreement was obtained between Lorain and Chandler, Conneaut and Chandler, Vermilion and Chandler, and Cleveland and Chandler, both as to trends in alkalinity fluctuations and absolute values. Of these, best agreement existed between Lorain and Chandler and Conneaut and Chandler for the years 1938-40. Significant coefficients of correlation were obtained for these latter pairs. For the wet years 1943-45 (Chandler's Bass Islands data for 1941-42 are not available) agreement between these location pairs

TABLE II

	Division	Baldwin	Average of Stations 47 and 48		
			Surface	Bottom	Surface and Bottom
Alkalinity					
June	93	92	97	93	95
July	93	92	96.5	94	95
Aug.	95	93	95.5	95	95
Sept.	96	94	97.5	98.5	98
Turbidity					
June	25	8	12	16	14
July	13	6	4	8	6
Aug.	13	6	7	8	7.5
Sept.*	16	7	10	10	10

*Station 47 only.

was less good, and significant coefficients of correlation were no longer attainable. Visual inspection for these latter years indicated that, of all plants, best agreement existed between Lorain and Chandler.

A time graph was next constructed on which were plotted the monthly maximum and minimum values for Lorain and for Chandler. Connecting these points resulted in two "bands" expressing the ranges of total alkalinity observed at the two locations. Overlapping of the two bands occurred in 51 months. Discrepancies in this plot prompted one further comparison. The average ranges of total alkalinity variation for the whole period of observation were computed for both Lorain and Chandler. This gave a single average range for each of the locations. The average range for each location was entered upon a time graph by centering it upon the monthly mean of each month. The two bands thus produced overlapped in 55 of the total 62 months (Fig. 8). This is taken as indicating that average conditions observed at Lorain reflect average conditions in the Bass Islands.

Before taking up turbidity, a discussion of the good agreement of onshore - offshore alkalinities during 1938-40 versus the poorer agreement during 1943-45 is in order. The various factors considered as possible agents in bringing about the observed disparity are: errors in sampling and determination of alkalinities; changes of intake location at filtration plants between 1938 and 1945; changes in personnel at filtration plants; prevailing winds; alkalinity of tributary streams; and runoff into the lake. These factors will be considered separately.

(1) Errors in sampling and determination of alkalinities. There is no basis for suspecting operational error, either at the filtration plants or in Chandler's observations.

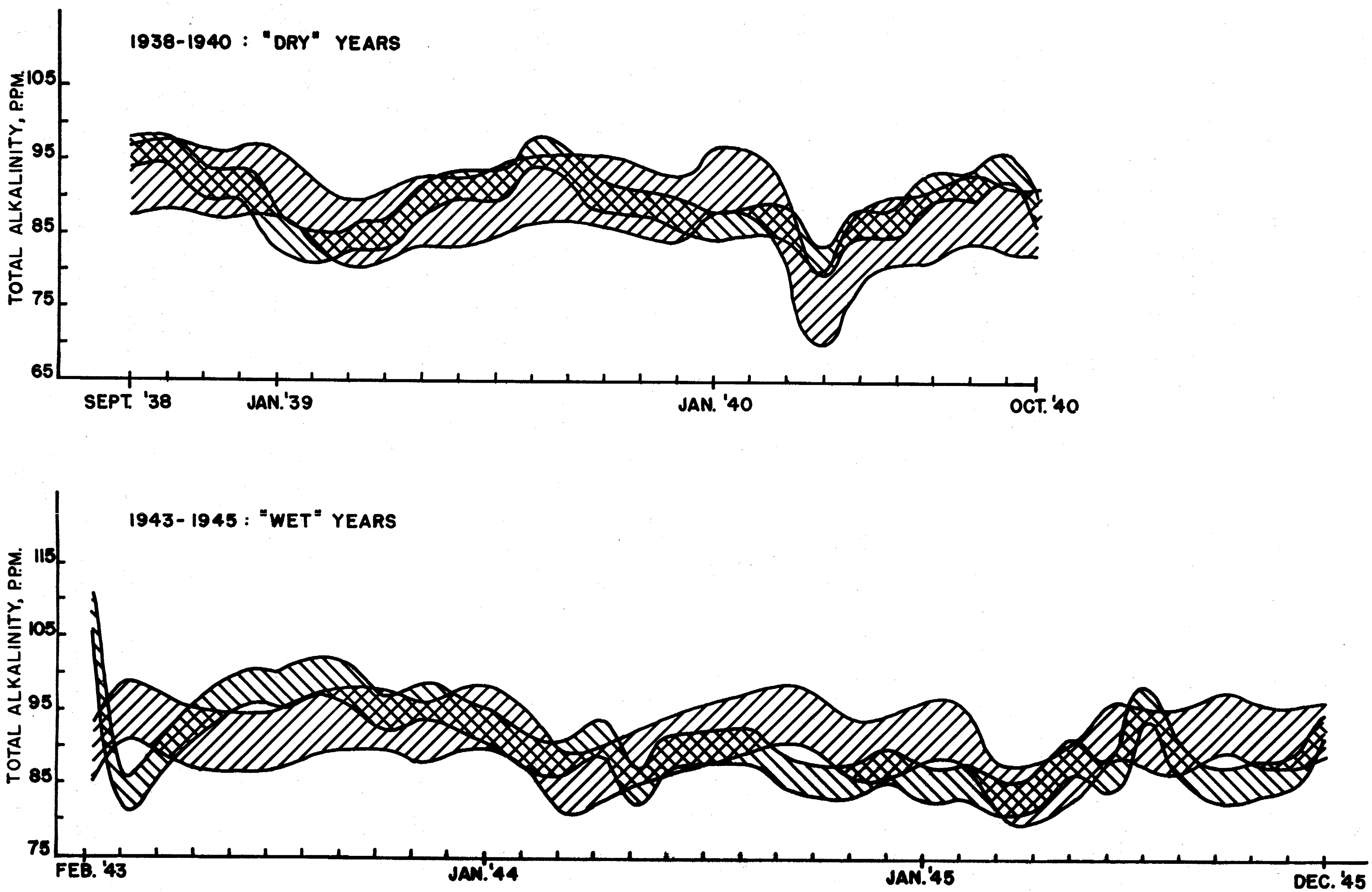

Fig. 8. Comparison of average total alkalinity ranges, Chandler (Bass Islands) and Lorain; 1938-40, 1943-45.

(2) Changes of intake location. None of the plants under consideration changed the location of their intakes during 1938-45.

(3) Changes of personnel at filtration plants. No changes occurred.

(4) Prevailing winds. It was thought that significant changes in direction of prevailing winds during 1943-45, as compared to 1938-40, might have resulted in alterations of average current patterns which in turn would have altered the distribution of total alkalinity. As a check on this hypothesis, average monthly wind directions and speeds were obtained for Cleveland from the United States Weather Review. Vector plots were constructed in order to obtain the average wind direction and speed for the two periods under consideration. Although monthly deviations from the average were present, no long-time differences occurred, the average directions being essentially the same for the two periods.

(5) Alkalinity of tributary streams. A number of Ohio streams tributary to Lake Erie were subjected to chemical analysis during 1950-52 as a part of the Lake Erie pollution survey conducted by the State of Ohio Water Resources Commission (State of Ohio, 1953). No direct or consistent relationship between actual alkalinity values of the streams and those observed at Lorain are apparent, other than the regular seasonal variations generally exhibited by total alkalinity in natural bodies of water.

(6) Runoff. This was the only factor in which there was a significant difference between 1938-40 and 1943-45. Among the gauged streams entering this portion of Lake Erie the Maumee, Sandusky, Cuyahoga, and Ashtabula were selected as indicators of runoff conditions. Using volume-of-flow data from the U. S. Geological Survey Water Supply Papers, the combined annual runoff of these four rivers was obtained by totaling their mean monthly discharges for each of the years 1938-45. Runoff during 1943-45 was about 50% higher than in 1938-40. The increase was general over the entire west-basin region; it included the Detroit River as well as the above rivers. It is thus established that the years of poorer agreement between onshore and offshore alkalinities were years of materially increased runoff.

Turbidity observations obtained by Chandler at Rattlesnake Island between 1941 and 1945 were in generally good agreement with those recorded at Lorain in the same years (Fig. 9). At both locations there are two "pulses" of turbidity per year, one in the spring and the other in the fall. The spring pulse contains higher turbidity values than does the fall. The pulses occurred at Lorain and Rattlesnake Island at about the same time, except in the falls of 1941 and 1942. Comparison of these twice-yearly pulses with the runoff of the Black River* at

*The Black River was not gauged; monthly discharge figures for it were obtained from the averages of the Sandusky and Cuyahoga Rivers, the nearest gauged streams. The monthly discharge rates per square mile of watershed for these two rivers were averaged and the average per square mile multiplied by the watershed area of the Black.

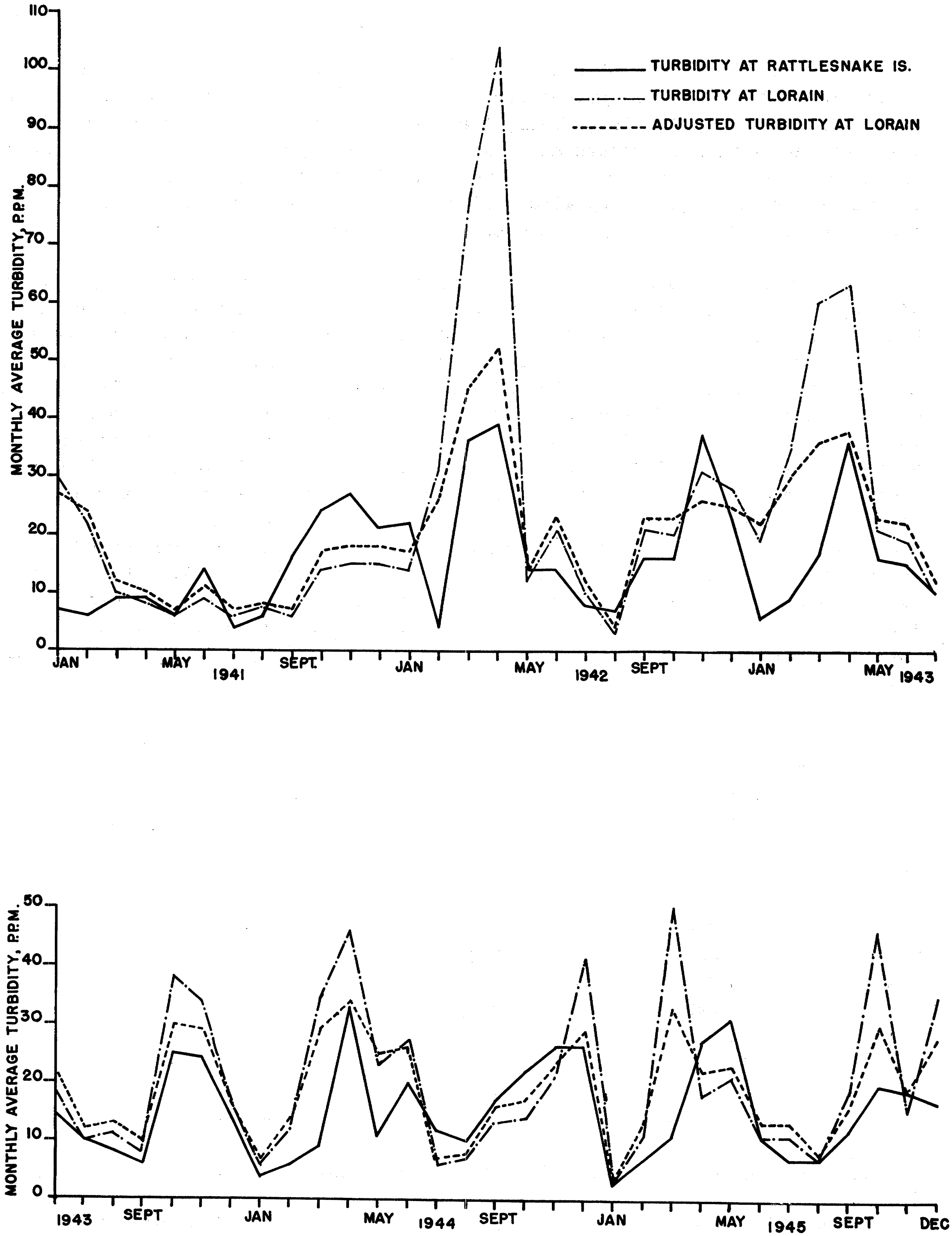

Fig. 9. Temporal variation of turbidity at Rattlesnake Island and Lorain, with adjusted values for Lorain; 1941-45.

Lorain reveals that the spring pulse occurs at the time of the late-winter-early-spring melt-off. The fall pulses occur during periods of greatly reduced river flows. The spring pulse is probably the result of suspended materials carried into the lake by runoff waters and also, to a less degree, of the spring plankton bloom which regularly occurs at this period. The fall pulse is probably due to bottom sediments suspended by winds and to the fall plankton bloom; the decreased runoff would contribute very little suspended material at this time.

In view of the favorable agreement in trends, and of the relatively few ppm difference in actual values, between the turbidity observations at Lorain and Rattlesnake Island the possibility of applying corrections to bring the two in even better agreement was considered. A scatter diagram was made in which average monthly values at Lorain were plotted against the difference in monthly means of Chandler and Lorain. This gave a curvilinear arrangement of points to which a curve was fitted by eye (Fig. 10). The curvature and scatter of points increased with decreasing turbidity values. A series of adjustment factors were derived from the slope of the curve by breaking the curve into a series of segments, taking each segment to be a straight line, and determining the slope of the segment. Adjustment factors were actually computed only for that portion of the curve lying above Lorain turbidities of 20 ppm. Turbidities below this value exhibited such a large scatter as to give unrealistic adjustment factors; an arbitrary factor of 1.20 has been used for this range. It appears to perform satisfactorily. Adjustment factors and the turbidity ranges to which they apply are:

Lorain Turbidity ppm		Adjustment Factor	
0-20	X	1.20	= Rattlesnake Island turbidity
21-25		1.10	
26-30		0.90	
31-35		0.85	
36-40		0.80	
41-45		0.75	
46-50		0.65	
51-80		0.60	
81-100		0.55	
101-		0.50	

The adjusted values of Lorain's turbidities are shown in Fig. 10.

It appears reasonable to conclude, on the basis of total alkalinity and turbidity observations, that physical-chemical data as obtained at the Lorain filtration plant can be used in the interpretation of open lake conditions obtaining in the west basin. In utilizing these on-shore data it should be carefully borne in mind that under prevailing winds (1) Lorain appears to be sampling

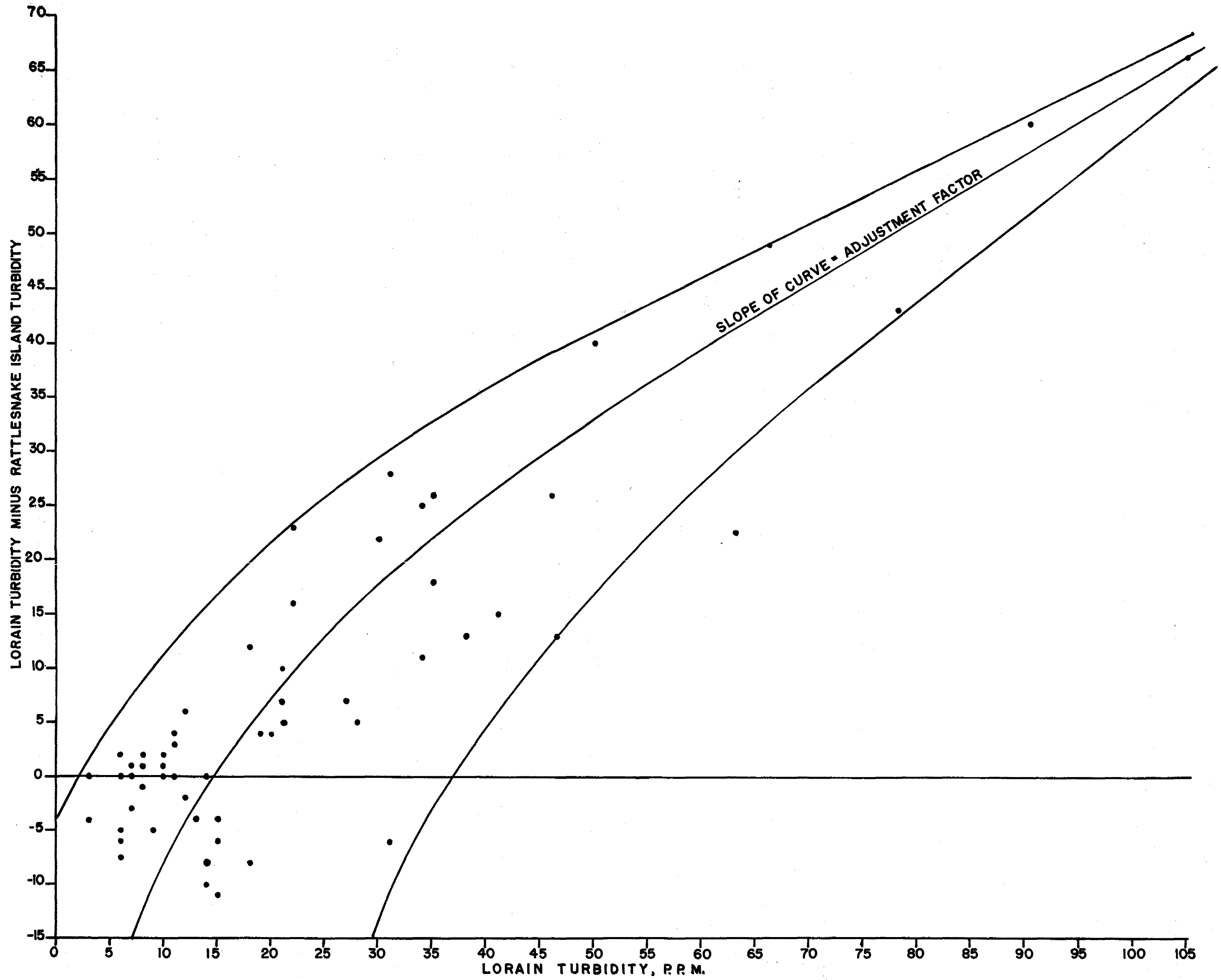

Fig. 10. Adjustment curve, Lorain turbidity to Rattlesnake Island turbidity.

the integrated water mass resulting from the mixing of the effluents of the Detroit River and the lesser streams entering the west end, principally the Huron, Raisin, Maumee, and Portage Rivers, and (2) data as obtained at Lorain are more representative of west basin conditions during seasons of normal or below-normal runoff than during periods of abnormally high runoff. It should also be remembered that during periods of winds from easterly quarters the lake circulation may be altered to the extent that Lorain may temporarily fail to sample west basin water.

REPRESENTATIVE STATIONS FOR THE CENTRAL BASIN

Since one of the chief parameters utilized in the selection of representative stations has been total alkalinity, it should at this time be pointed out that in the central basin there is a north-south horizontal gradient of total alkalinity in which values decrease toward the south. This situation is the reverse of that encountered in the west basin, in which lower alkalinity values are found in the north where the Detroit River enters the lake, and higher values in the south where relatively large amounts of admixed Maumee River water occur. The gradient existent in the central basin is apparently due to the bedrock formations underlying the lake, and to the very high alkalinity values found in the tributary streams of the Canadian shore.

Both the central and east basins are underlain by shale and limestone; in the central basin the limestone is confined to a narrow region roughly parallel to the north shore. The remainder of the basin is underlain by shale. The dissolution of limestone by carbon dioxide in the bottom waters and the upwelling of these waters along the north shore may account for the higher total alkalinity values found in the northern portion of the central basin.

The north-south gradient in alkalinity appears in the Buffalo Museum "Shearwater" data of 1929 (Fig. 4) and the University of Western Ontario data of 1947-53.

Assessment of representative stations for the central basin was largely on the basis of the 1929 "Shearwater" data, as data obtained by the University of Western Ontario was practically all confined to the northern portion of the basin. Although the data of "Shearwater" cruise 2 of June, 1929, were the only data suitable for the construction of a circulation pattern, total alkalinity and turbidity data from the remaining three cruises in July, August, and September 1929 were utilized in the analysis of the representativeness of central basin stations. Cleveland and Erie were considered as the possible south-shore representative stations for this basin, they being the only two which had not been eliminated from consideration on the basis of intake location, pollution effects, or some other factor.

From circulation evidences, as well as geographic location, it appeared that Erie possessed better qualifications than Cleveland for the position of representative station for the central basin. The Erie intakes (there are two

plants, with intakes close to each other) appeared to be in such a position as to sample an integrated product of the easterly south shore current and the cross lake current from Long Point. The surface current pattern indicates that water from both these sources might be brought past the Erie intakes. Cleveland, on the other hand, is so far west as to be sampling predominantly the water of the easterly south shore current only, and further, analysis of the circulation suggests that the Cleveland intakes may at times sample water which is predominantly an unmodified effluent of the west basin.

From "Shearwater" cruise 2 were available total alkalinities, turbidities, and water temperatures which could be used in analyzing the representativeness of Cleveland and Erie. It is obvious that as complete an analysis could not be performed here as was the case with Chandler vs. Lorain, since in the latter case data for the west basin were available over a period of years.

Total alkalinity and turbidity observations obtained at Cleveland's Division and Baldwin filtration plants in 1929 were compared with values of these parameters at "Shearwater" stations 47 and 48.

These stations were located 2 and 14 miles, respectively, north-northwest of the two plant intakes, and the depths at the stations were fairly comparable to the intake depths. The depth of the Baldwin intake is 28 feet and that of the Division intake 36 feet; station 47 was located in 38 feet of water and station 48 in 44 feet. The comparisons of the two filtration plants with data from stations 47 and 48, for each of the four cruises, are summarized in Table II.

In the case of total alkalinity, best agreement is between the Division plant and the average of the bottom values from stations 47 and 48. Both plants tended to run slightly below the surface values as observed at the stations.

The best agreement of turbidity values lay between the Baldwin plant and the average bottom values of the two stations.

In summary, the total alkalinity and turbidity data as obtained by the two Cleveland filtration plants are, to a fair degree, representative of these two parameters as they occur somewhat farther out in the lake. Evidence derived from the circulation pattern of the lake, however, indicates that at best Cleveland is sampling water from the extreme western portion of the central basin, and may frequently sample relatively unmodified west basin water. The strong turbidity gradient along the south shore in the vicinity of Lorain and Cleveland as observed by "Shearwater" cruise 2 (Fig. 3) is indicative of the presence of west-basin water.

At Erie, observations of total alkalinity, turbidity, and water temperature as obtained at the Chestnut Street filtration plant were compared with values of these parameters as obtained by "Shearwater" cruise 2 (Erie's West filtration plant did not become operative until 1932). Comparisons were made in two ways; first, all "Shearwater" stations in the central basin, including those to a dis-

tance five miles east of Erie, were combined to obtain mean values of total alkalinity and turbidity for surface, bottom, and average of surface and bottom. This was done for each of the cruises, that is, June, July, August, and September. Secondly, stations 37, 38, 47, and 48 were similarly combined to obtain average values for each of the cruise months. These stations lay, respectively, three miles north of Ashtabula, 3 miles north of Fairport, and 2 and 14 miles NNW of Lorain. These four stations were indicated by the circulation pattern as lying within the eastward south-shore current which passes the Erie intakes; they were compared, separately from all the central-basin stations, with the Erie data in an effort to determine whether Erie might be more representative of this water than of the central basin as a whole. Stations 37, 38, 47, and 48 will hereafter be referred to as "selected stations." Temperature data from the "Shearwater" cruises were treated similarly to alkalinity and turbidity, with the following two exceptions: (1) Temperature was obtained at each station at surface, 10 meters, and bottom. Only the surface and 10 meter observations were compared to the Erie values, since these were nearer the intake level of the plants and gave a more realistic test of Erie's representativeness. (2) In addition to data from the June, July, August, and September cruises, temperature data from a May, 1929, cruise were available, although alkalinity and turbidity data for this cruise were lacking.

Comparisons of averaged "Shearwater" data and Erie's Chestnut Street plant's monthly average data are summarized in Tables III and IV.

It may be seen from Table III that, compared to the average of all stations, alkalinities observed at Erie are consistently low, by 4 to 7.5 parts per million. Erie's values agree best with the bottom values of the selected stations, which were located within the south shore current. The Erie intakes appear, then, to sample predominantly water from the south shore current, rather than a well integrated product of water from the entire central basin. Erie plus 3 ppm would appear to give a working estimate of selected-station alkalinities under most conditions.

That Erie is not representative of the northern and western parts of the central basin is shown by a comparison of total alkalinity data at Erie with data obtained at University of Western Ontario stations 2, 3, 4, and 5 between 1947 and 1953 (Appendix II). These stations were situated 6, 14, 20, and 26 miles south of Point aux Pins. Alkalinity values at Erie were as much as 28 ppm below those observed at UWO stations, and only at one time were the Erie values less than 11 ppm below the station values. The existence of a decreasing north-south horizontal gradient of total alkalinity in the central basin has been discussed above and is reflected in these two sets of data.

Turbidity values observed at Erie are consistently and irregularly higher than those of the open lake as indicated by the "Shearwater" data. This is true for both "all stations" and "selected stations." It is likely that turbidity at Erie is influenced locally by the sediment-suspending effects of wind or current action, and it is to be expected that the plant data should reflect these influences in higher turbidities.

TABLE III

	All Stations			Selected Stations			Erie
	Surface	Bottom	Surface and Bottom	Surface	Bottom	Surface and Bottom	
Alkalinity							
June	99	97.5	98	95	94	95	92
July	101	98	99.5	96	95	95	92
Aug.	97	96.5	97	97	95.5	96	93
Sept.	98	98	98	97.5	99	98	93
Turbidity							
June	4	6	5	9	11	10	12
July	3	6	5	5	6	5	10
Aug.	2	5	4	5	6	6	16
Sept.	4	5.5	5	7	7	7	20

TABLE IV

Month	Temperature, °C				
	All Stations		Selected Stations		Erie
	Surface	10 Meters	Surface	10 Meters	
May	8.4	6.6	9.8	7.8	11.7
June	17.6	13.2	18.0	14.5	17.4
July	20.2	17.7	21.6	19.1	21.6
Aug.	20.9	20.0	21.4	20.7	21.8
Sept.	19.4	19.4	19.7	19.6	20.3

From Table IV, it may be seen that agreement of intake temperatures at Erie with those observed by the "Shearwater" is excellent. Erie's values coincided more closely with surface temperatures than with 10-meter temperatures; correlation of Erie with the selected stations is a little better than with the entire basin, but the difference is slight. It should be noted that agreement was least good in May, when the intake water was warmer than that of the open lake. This is to be expected, since this correlates with the season of spring warming, when near-shore waters would have attained a higher temperature than those farther offshore.

Comparisons of intake temperatures at Erie were also made with surface temperatures (both in centigrade) observed at University of Western Ontario stations 2, 3, 4, and 5. They are summarized in Table V.

TABLE V

	1947		1948		1949		1950		1951	
	Erie	UWO	Erie	UWO	Erie	UWO	Erie	UWO	Erie	UWO
April			8.2	4.5						
May							9.6	11.9	11.2	11.5
June			16.5	16.0	18.4	19.6*	16.8	16.9	15.7	18.6
July	18.8	22.1*	20.2	20.3	20.1	24.4*	20.3	20.8	21.6	22.9
Aug.	22.2	25.7	22.7	23.5*	24.3	24.2	22.5	21.9*	22.8	23.2
Sept.	22.3	18.6			18.6	19.9	17.9	22.4*		
Oct.							16.2	19.4*		

*Based on single observation from station 2.

Agreement of Erie intake temperatures with those as observed at UWO stations is, for the most part, quite good. Once again, the effects of alongshore warming in the spring are indicated in the one set of April temperatures, where the water at Erie was nearly twice as warm as that in the open lake. More rapid autumnal cooling of the shallow onshore water is shown in the September and October data of 1949 and 1950.

It must be remembered, as has already been pointed out, that strict comparability between observations obtained at Erie and those from the open lake cannot be implied, since it has been necessary to compare monthly averages based on a relatively large volume of data at Erie with either single days' observations, or averages based on no more than four observations, from the open lake. Considering the paucity of open lake data available, the comparability that has been obtained must be considered very good.

On the basis of total alkalinity, Erie must be considered a good representative station for only the southern half of the central basin. In regard to water surface temperatures, however, those observed at Erie do not differ materially from those of the entire basin. This apparent discrepancy is resolved when one considers that surface temperatures throughout the basin are controlled by very nearly the same climatic regimen and should not exhibit too much variability, except in regions of upwelling. One appears to be justified, then, in accepting the intake temperatures at Erie as being representative, within a few degrees, of the average surface temperatures existing anywhere within the central basin. The strongest exception to this representativeness would be in comparing Erie's temperatures with those along the north shore, where the existence of the counterclockwise eddies appears to result in upwell-

ing of cooler subsurface water, the temperatures of which would not be typical of surface temperatures over most of the basin.

Since Erie can be considered chemically representative of only the southern half of the central basin, conditions obtaining in the basin as a whole could be more accurately depicted if there were two representative stations, one on the south shore (satisfied by Erie), and one on the north. Although a number of municipalities in the province of Ontario possess filtration plants which obtain water from Lake Erie, none of these make routine physical-chemical analyses of raw water as far as this investigation has been able to determine. Analyses of intake water at Port Stanley, made by the Industrial Minerals Division, Mines Branch, Canada Department of Mines and Technical Surveys (Thomas, 1954) indicate a degree of comparability between this water and that sampled by UWO stations 2, 3, 4, and 5. Intake water at Port Stanley was subjected to complete analysis once monthly from February 1948 to February 1949. During this period the UWO stations were visited during June, July, August, and September. The average total alkalinity for the four samples obtained during these months at Port Stanley was 100 ppm; the average from all depths at the UWO stations was 106 ppm. Considering once again the scanty data available for comparison, this is good agreement. Centigrade temperature data from the two sources were compared on a month-to-month basis.

	April	May	June	July	August	September
University of Western Ontario	4.2	---	12.7	16.3	20.3	21.6
Port Stanley	0.6	3.3	4.4	15.6	18.3	15.6

The notable tendency of the Port Stanley temperatures to remain consistently below those as observed at the open-lake stations is probably due to upwelling occurring near the north shore in the Port Stanley vicinity, caused by the previously mentioned eddy occurring here. The proximity of Port Stanley to this upwelling makes its value as a representative station questionable, since it would, at different times, be effectively sampling different depths. Hence, variability in observations would have to be assessed partially on an unknown basis of effective sampling depth.

The deduced pattern of surface circulation indicates the possibility of Port Burwell as a better location for a north shore representative station, since it lies at the extreme eastern end of the eddy, and near the area of strong onshore current shown by the FWS drift bottle returns. It is not known at present whether this municipality has an intake in Lake Erie; if water is being drawn from the lake, the initiation of a program of obtaining observations such as total alkalinity, turbidity, and temperature, might well result in the accumulation of a valuable body of limnological data.

REPRESENTATIVE STATIONS FOR THE EAST BASIN

The only possible representative station for the east basin is the Erie County (New York) Water Authority filtration plant located at Woodlawn, N. Y. The Niagara-Mohawk power station at Dunkirk, N. Y., obtains physical-chemical data, but its records are available for only a few years back and assessment of its representativeness is impossible. Because Woodlawn has obvious weaknesses (discussed below) Dunkirk should be evaluated as soon as simultaneous data are available.

Data of 1929 from the Woodlawn plant were compared with open-lake data obtained by the "Shearwater" in the east basin in 1929 (1928 data are also available from previous "Shearwater" cruises, but data from Woodlawn do not include that year.) Comparisons were made of total alkalinity, turbidity, and temperature. The procedure was similar to that used for Erie, in that data from Woodlawn were compared with monthly averages of observations from the entire east basin, and also with certain "selected: stations which, according to the deduced circulation pattern, lay up-current from the plant's intake. The latter stations were all near the south shore, extending from just off Woodlawn to about the Pennsylvania-New York state line.

Results are summarized in Tables VI and VII.

TABLE VI

	All Stations			Selected Stations			Woodlawn
	Surface	Bottom	Surface and Bottom	Surface	Bottom	Surface and Bottom	
Alkalinity							
June	100	98	99.5	96	95	96	93
July	99	98	99	98	97	97.5	90
Aug.	98	97	97.5	98	97	97	91
Sept.	98.5	98.5	98	98	97	98	99
Turbidity							
June	13	16	14	14.5	15	15	13
July	6	20	13	8	9	8	7
Aug.	4.5	13	9	6	7	6.5	8
Sept.	0.5	8	4.5	0.6	1	1	13

TABLE VII

Month	Temperature, °C						Woodlawn
	All Stations			Selected Stations			
	Surface	10 Meters	Bottom	Surface	10 Meters	Bottom	
June	13	11	8	12	---	12	17
July	19	17	12	20	---	18	20
Aug.	20	18	14	21	---	20	18
Sept.	21	20	16	21	---	20	15

Total alkalinity as observed at Woodlawn is consistently lower than open-lake observations for the east basin, as obtained by the "Shearwater." The tabulations of Table VI indicate that this is true for both "all stations" and "selected stations," except for September, when the average value at Woodlawn for that month closely approximated open-lake values. Order-of-magnitude agreement is quite good, however, and lower alkalinities at Woodlawn may be due largely to the effects of acid waste effluents from steel mills which located in that vicinity. Probable variations in quantity of acid waste make a correction factor futile.

Average monthly values of turbidity at Woodlawn agree well with those from the "selected stations," and, for the most part, fairly well with those from all stations in the east basin. The only notable discrepancy is in September, when local disturbances (probably winds) apparently resulted in higher turbidities in the vicinity of the intake.

Temperature observations from Woodlawn do not agree as well with open-lake data as do the plant data at Erie. This may be largely due to the plant's being located on the extreme east end of the lake, where the intake is exposed to the full effect of the internal seiche, the magnitude of which can be quite large. This might explain the lower temperature at Woodlawn for September, when the average of 15°C corresponded closely to the average of bottom temperatures for all stations,whereas in June, July, and August intake temperatures corresponded more closely to average surface temperatures for both "all stations" and "selected stations."

LAKE ERIE REPRESENTATIVE STATIONS: A SUMMARY

It has been shown that for each of the three basins of Lake Erie, a filtration plant exists whose raw-water data correlate sufficiently well with open-lake data to justify their establishment as the most representative stations for

their particular basins. Lorain, Ohio, and Erie, Pennsylvania, chosen as representative stations for the west and central basins, respectively, appear to be more reliable than Woodlawn, New York, the one evaluatable station for the east basin. Waste effluents from steel mills and seiche activity appear to affect the representativeness of alkalinity and temperature data at Woodlawn. The intakes at Lorain and at Erie appear to be relatively free from the effects of local pollution and seiches, and it is believed that data obtained at these two plants are sufficiently indicative of open-lake conditions to permit their application to practical limnological problems, particularly in regard to the assessment of long-term physical-chemical conditions in the lake.

When and if Erie and Woodlawn are seriously used in "watching" the trends within the lake, their actual degree of representativeness should be more definitively determined by more offshore cruises. Scarcity of offshore data has been a serious limiting factor in their assessment. Dunkirk, New York, may be a much better representative station for the east basin and should be evaluated as soon as possible.

A REPRESENTATIVE STATION FOR LAKE MICHIGAN

Through the kindness of Mr. Russell L. Johnson, Engineer in Charge, Northern Peninsula Office, Michigan Department of Health, we are able to indicate a representative water plant on Lake Michigan. In collating local wind and circulation near Muskegon, Michigan (as indicated by Ayers et al., 1958) with raw water temperatures from the recording thermometer at the Muskegon water plant, Mr. Johnson has very clearly shown that under different winds Muskegon samples both surface water from about 20 miles out in the lake and subthermocline water from the region outside Muskegon.

His studies (personal communications) show that under south, southwest, or west winds surface waters from the open lake approach Muskegon. On the second day of winds from these directions notable rises in raw water temperature occur, and by the fourth day of such winds isotherms originally about 20 miles offshore are being sampled by the intake. Referring to Fig. 4 of the Lake Michigan paper (Ayers et al., op. cit.), Mr. Johnson says, "Figure 4 shows that, on June 28, the 17° isotherm for the surface water was located several miles offshore at Muskegon. On June 29, according to Figure 15, this isotherm had reached shore in this part of the lake. At intake level off Muskegon, the water temperature started rising at about 0100 hours on June 29, the day of Synoptic Cruise V. It reached 17°C (62.6°F) late in the day on June 30 or early on July 1." Winds at Muskegon were from the south for six days beginning on June 27.

His studies also show that the atypical east-shore south current observed in Lake Michigan on 9 and 10 August 1955 in Synoptic Cruises VI and VII probably began on 7 August, for on that day the raw-water temperature at Muskegon began a sharp decline which lasted through 9 August, and were only beginning to rise on the 10th. During the sharp decline, temperature fell from 80.0°F (26.6°C)

to 45.0°F (7.2°C) between 0630 of the 7th and 0430 of the 9th. Figures 5, 16, 28, and 41 of the Lake Michigan paper all show 7.2° water to be subthermocline water. This temperature break accompanied north winds and east winds (offshore winds) that began on August 7th and continued for at least five days.

Mr. Johnson's studies also indicate that northwest winds cause strong upwelling at Muskegon.

It appears reasonable to believe that Muskegon on the fourth day of winds from the south, southwest or west is sampling surface water from about 20 miles (estimated) offshore. It also is reasonable to believe that Muskegon on the third day of winds from the northwest, north, northeast, or east is pumping subthermocline water representative of the hypolimnion of the deep basin outside Muskegon.

Mr. Johnson has authorized our use of the above review of his studies.

A TECHNIQUE FOR DETERMINATION OF WIND PATTERN OVER A LAKE

Basic to the study of properties of a large body of water is knowledge of its currents. The distribution of water properties such as alkalinity and turbidity is influenced by the movement of lake currents. Current variations are brought about by two principal factors; 1) temperature distribution of the water, and 2) wind at the lake-atmosphere interface.

The techniques of dynamic height determination derived from considerations of the density distribution of water in order to compute water currents are well known in oceanography and have been used with success in previous studies of some of the Great Lakes (Ayers, et al. 1958; Ruschmeyer and Olson, 1958). The dynamic height method yields an integrated depiction of temperature effect and the wind-distributed field of density. In this depiction the temperature factor is semi-conservative and varies at a relatively slow rate, while the wind factor varies on a day-to-day basis. The wind pattern over a lake, then, is the dominant factor in the pattern of water currents in the lake.

For large bodies of water that are relatively shallow, such as Lake Erie, currents are much more rapidly changed than in deeper lakes of comparable area. This is because shallow water does not represent as great a momentum sink as does deep water. It has been found that current patterns in western Lake Erie, for example, are variable, and frequently vary on an intra-diurnal time scale (FWS Cruise Report III, Ayers, 1958). There is also evidence elsewhere (Saginaw Bay, Johnson, 1958) to indicate the wind-produced changes in shallow water movement may take place with as little as two hours subjection to a new wind regime. It is important, therefore, that the wind field be determined as accurately and frequently as possible.

A technique of kinematic analysis of the atmosphere, known as the streamline wind analysis method, makes possible an accurate computation of the wind-produced currents which affect the distribution and transport of variables that make up the water quality (e.g., alkalinity, turbidity, chemistry). It is also a valuable means for reconstructing the wind regime and current patterns in the Great Lakes at any time during the past 60 years. It is, therefore, both a climatological and synoptic aid in water current analysis. The technique utilizes reports of the wind vector from many observers taken simultaneously; hence analyses made from these data are truly synoptic.

The frequency of reports (and hence possible analyses) is a function of their history. Before the onset of World War II, the frequency of reporting was once per day. After the close of the war, reports became available on an hourly basis. Data density has increased in like manner. For example, in 1899, there were four stations surrounding Lake Erie that reported wind data once per day. At present, the number of stations which surround western Lake Erie alone number 21, all of which make hourly reports of most meteorological variables including the wind vector. Some wind records of this group are autographic. In addition to the hourly stations, Powers et al. (1958) have shown that there are ten Coast Guard stations around the western basin of Lake Erie reporting the wind vector at either 4- or 6-hourly intervals. On a once-per-day basis there are an additional five water plants that surround the same area of Lake Erie that report the wind vector. Finally, there is a variable number of lake vessels that are equipped with anemovanes which report periodically when operating more than 4 miles from shore. Not counting the vessels, there are three dozen sources for wind data over the western basin of Lake Erie alone—a ten-fold increase in data density since the turn of the century. The hourly wind reporting stations in the vicinity of all the Great Lakes which are available at present are represented by the station circles shown in Fig. 11. Each station reports all meteorological variables including the wind vector.

The basic difficulty in making a wind analysis is not just a function of the data density, but primarily is dependent on the fact that the wind is a vector quantity. It is possible to draw charts and graphs of vector quantities, but it is difficult for the analyst to account graphically for the variation of the vector by one system of lines or isopleths. It is simpler and more accurate to analyze the vector in terms of its two scalar components, speed and direction, by preparing a graph of each scalar separately.

Figure 11 shows the first step necessary in preparing an accurate analysis of the wind direction field. The two digits above the station circle are the reported wind direction in tens of degrees reckoned clockwise from north (36), calm being code 00. The wind data shown are those actually recorded at 1300 EST 23 October 1958.

With a field of numerical values at hand to express the wind directions, equal-valued lines called isogons may be constructed. The purpose of the isogons is two-fold. First they give continuous representation of the wind direction

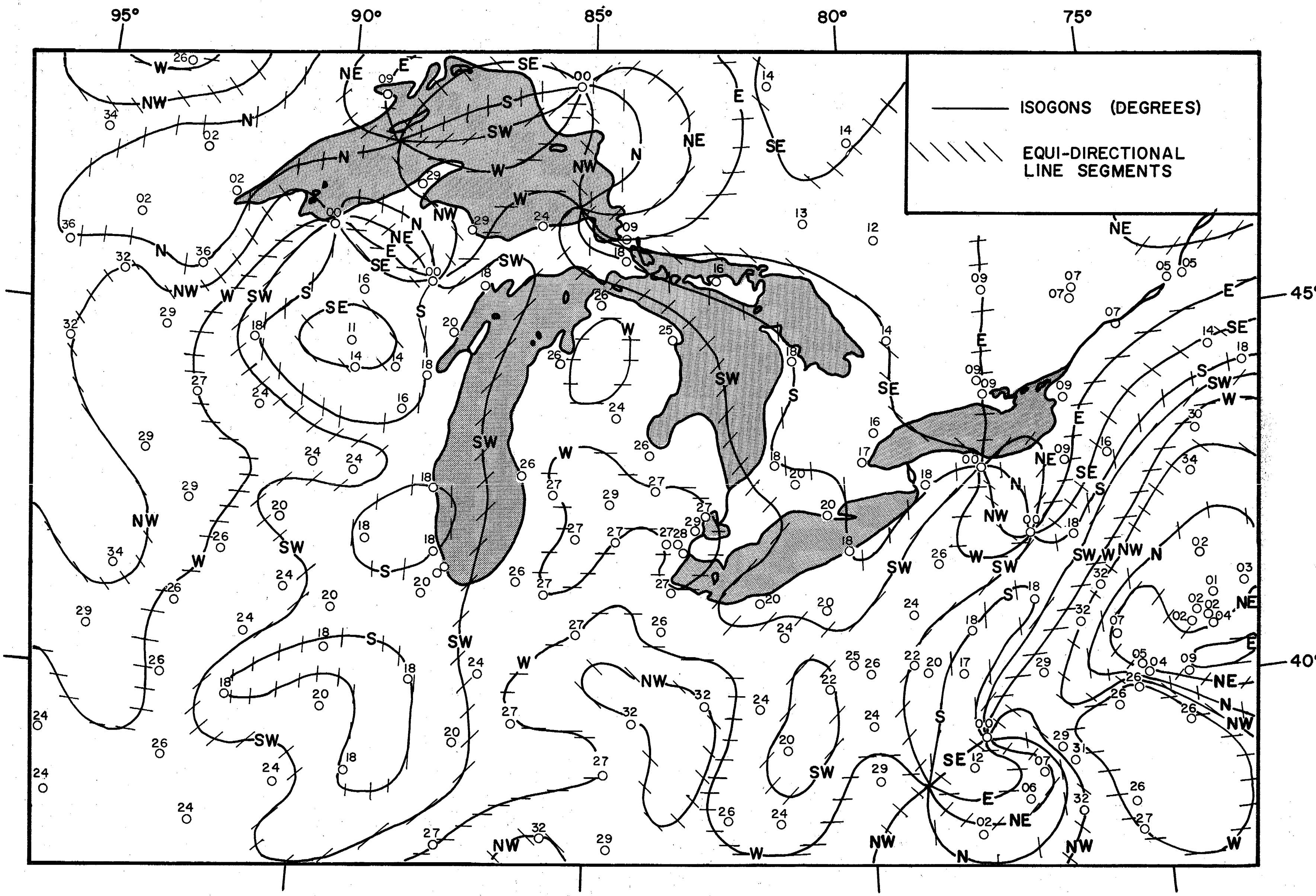

Fig. 11. Isogon analysis. Data above station circle wind direction in tens of degrees. Solid lines isogons. Broken lines equi-directional line segments.

field. That is, everywhere along any one isogon the wind direction is the same. The isogons also provide interpolated information of the wind direction between stations. In Fig. 11, the isogons are labeled by letter abbreviations, NE, SW, etc.

It is difficult to draw, directly, the streamlines which depict the wind direction field because of the lack of information between stations. Only a crude first approximation to direction field is possible by the direct approach. First, direction arrows must be constructed at each station to show the wind direction graphically. Then streamlines may be drawn, but with confidence only if the data density is high. In only a few locations of the United States (viz., around the major metropolitan centers) is the station coverage dense enough to approximate the detail possible from an isogon analysis. In the interests of accuracy, therefore, the isogon procedure is recommended because it multiplies the density of the data field.

The second step in preparing the streamline analysis is to construct short line segments across each isogon. Each line segment is oriented according to the wind direction of its isogon. That is to say, all line segments on the "north" and "south" isogons, for example, are drawn parallel to the local meridians no matter how the isogon itself varies across the chart; all segments on NW and SE isogons point in these directions; etc. The number of segments drawn is completely arbitrary.

What has been accomplished by the procedure so far described, and illustrated in Fig. 11, is to give the analyst a chart composed of as many "wind observations" as he desires. Instead of being restricted to wind data reported by the stations alone, he now has a limitless number of wind directions by which to construct streamlines to show the air-flow at a given moment. In actual practice, isogon intervals of 30 to 45 degrees (those of Fig. 11 have an interval of 45°) with line segments one or two latitude degrees apart is a sufficiently detailed field of data from which to draw streamlines.

The third step in the procedure is illustrated in Fig. 12. For simplicity, only the line segments from Fig. 11 are reproduced. The pattern of air flow is shown by the solid streamlines which are constructed so as to be everywhere parallel to the line segments. This is the only requisite on the construction of streamlines; the speed of the wind is not involved in this analysis. Streamlines can fork and join, but only asymptotically. Exceptions are at singular points where the wind is calm and the wind is considered omni-directional. The number of streamlines constructed is arbitrary.

Figure 12 is a completed analysis of the wind direction field over the Great Lakes and vicinity. The complete wind field, however, is not specified until its speed is analyzed. This is shown in Fig. 13 where the two-digit figure appearing beneath the station circles is the wind speed in knots. The dashed lines are equal-speed isopleths (isotachs) drawn to the numerical data in intervals of 5 knots. The patterns in the figure show the variation in speeds of the air motion.

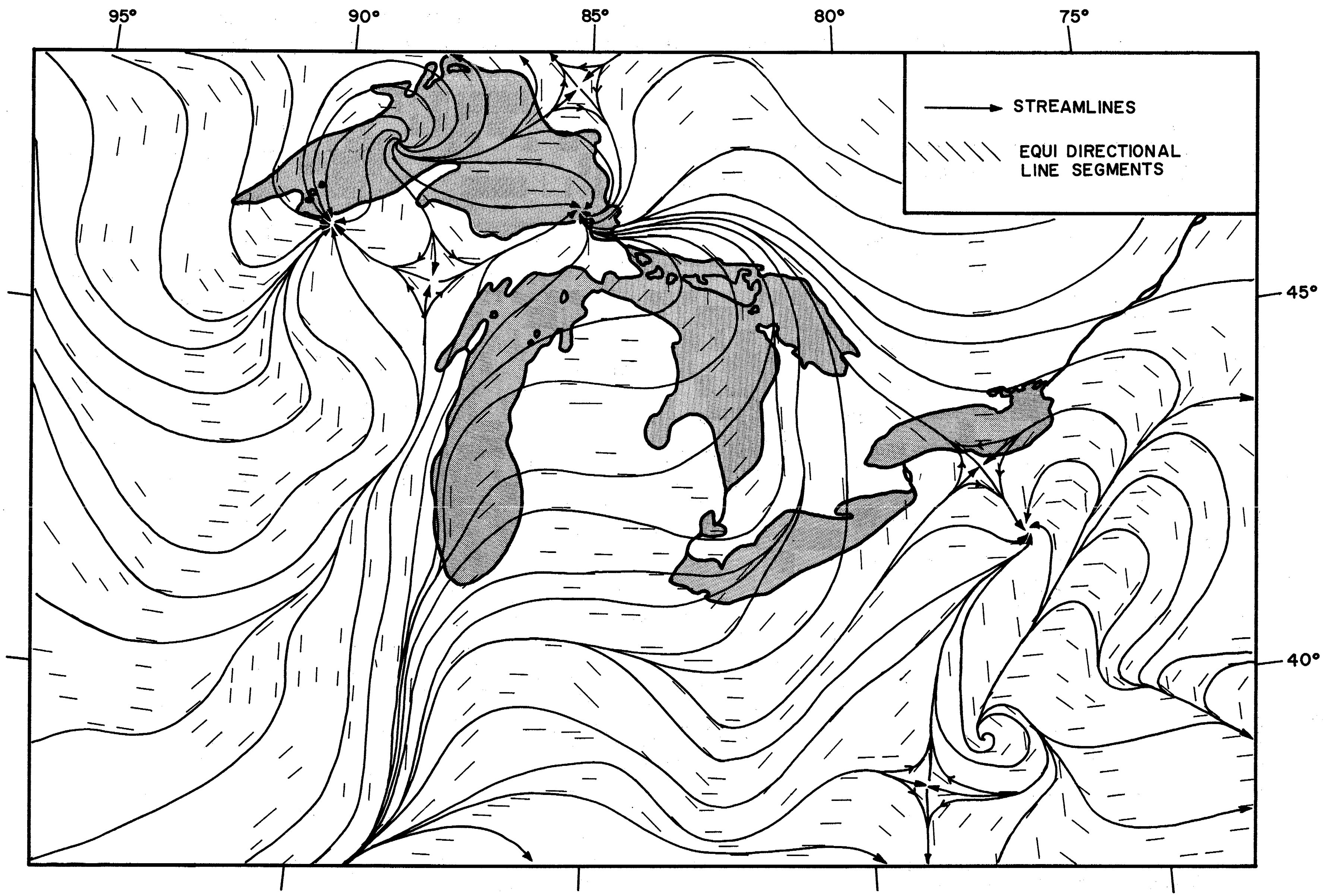

Fig. 12. Streamline analysis. Broken lines equi-directional line segments. Solid lines streamlines.

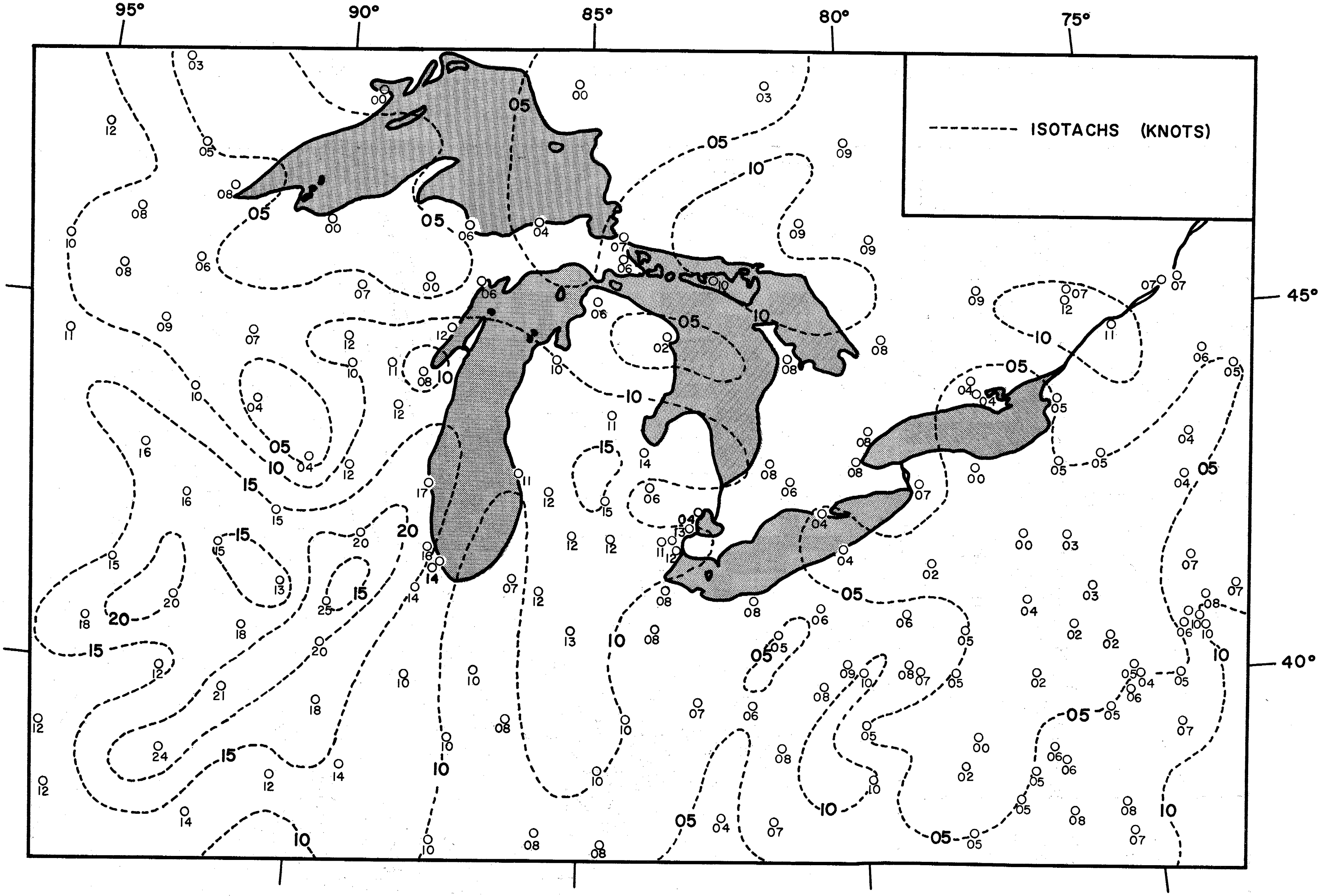

Fig. 13. Isotach analysis. Data beneath station circle wind speed in knots. Dashed lines isotachs.

When isotachs are superimposed on streamlines the resulting chart gives a complete representation of the horizontal wind field. This is shown in Fig. 14. The speed and direction of the wind at any point over land or lake is given either directly when the streamlines or isotachs pass over the point, or by linear interpolation between isopleths when the desired location falls between them. The effect of the wind stress on surface water movement can be computed at this point by any suitable technique such as those described by Ayers et al. (1958) and Hunt (1958).

The streamline technique of representing the wind field at the water-air interface will give more definitive surface current patterns than from conventional techniques. This means increased knowledge of trajectories of water sampled for such parameters as alkalinity, chemistry, turbidity, and temperature. The wind field portrayed will be no more accurate than is commensurate with the accuracy and density of individual data sources, but from a given set of data the technique provides the most accurate analysis of the wind velocity field. Historical as well as present wind data may be analyzed by the streamline technique.

RAINFALL IN THE LAKE ERIE BASIN SINCE 1810

As a part of the accumulation of the historic background of the Lake Erie aquatic environment, searches of the literature for old meteorological data have been carried out. During these searches we have uncovered sufficient rainfall data to allow the reconstruction of a practically continuous rainfall graph extending back to 1810. As is also the case with lake levels, it is greatly to be desired that rainfall records be extended back into the period when the Great Lakes watersheds were in essentially full-forest condition.

The oldest rainfall records pertaining to the Ohio region are from a gauge maintained by a Dr. Hildreth of Marietta, Ohio, during the years 1819-1823 and 1828-1832. These records, however, overlap with records from a gauge at the Pennsylvania Hospital in Philadelphia during the years 1810-1815, 1815-1819, and 1827-1837. The overlap of the Marietta and Philadelphia records covered the 5-year period 1828-1832. The data for the overlap period are in terms of total rainfall and mean annual rainfall during the periods. Figures for the individual years are not available. The mean annual rainfall at Marietta was slightly greater than that at Philadelphia and all the data from Philadelphia have been increased by an amount sufficient to make Philadelphia equal to Marietta during the period of overlap. The corrected Philadelphia data undoubtedly are in error, but to date they are all that are available for the 1810-1827 period. They have been used, as corrected, in the computation of the mean annual rainfall of the 1810-1958 period (discussed below). No attempt has been made to correct the Marietta records to stations within the Lake Erie basin. This may be attempted later if circumstances indicate it to be desirable. As the data now stand they show a good degree of agreement with the old lake levels (discussed later):

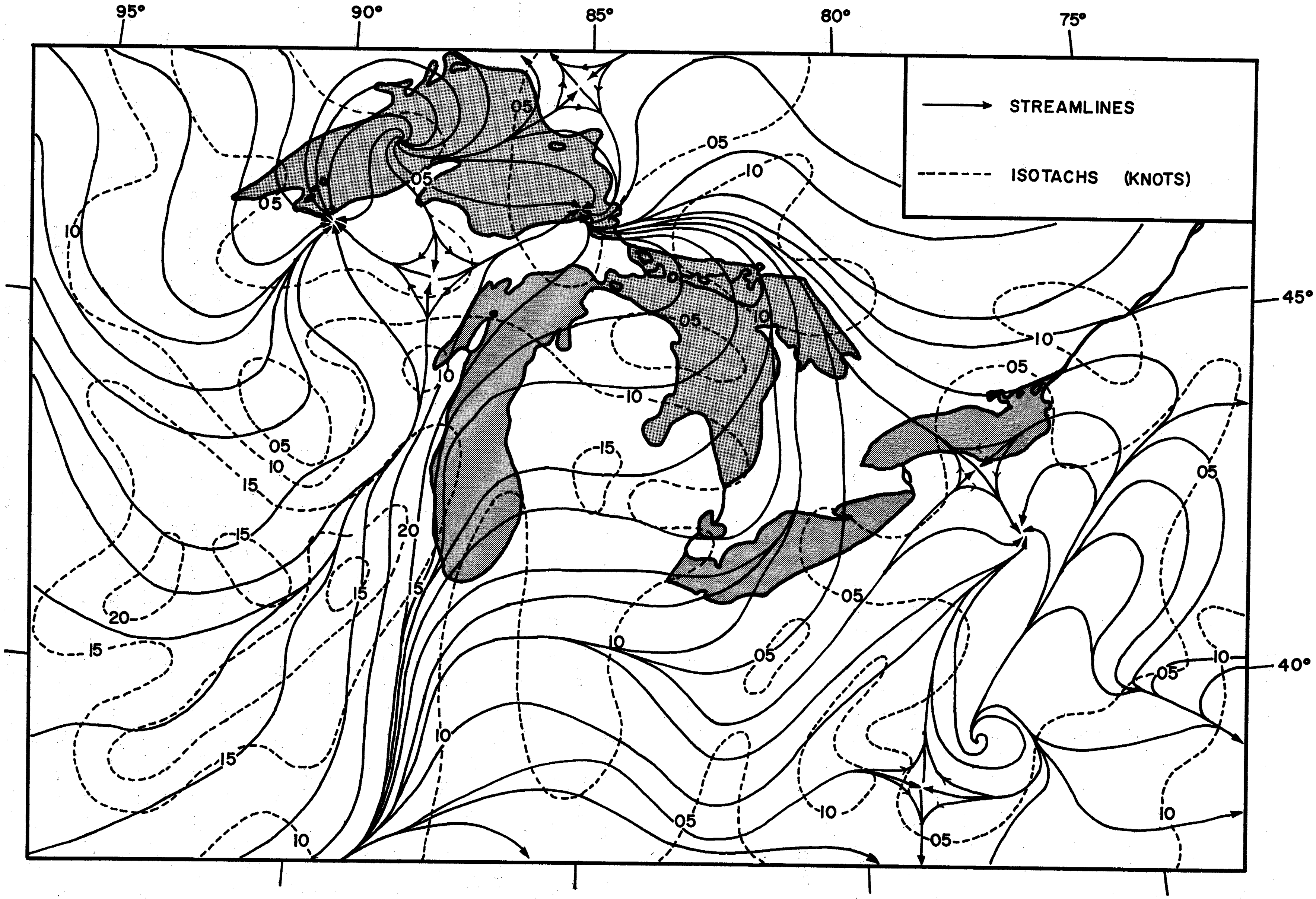

Fig. 14. Completed streamline-isotach analysis for 1300 EST, 23 October 1958. Solid lines streamlines; dashed lines isotachs.

high lake levels following at the end of periods of above-average rainfall and low lake levels coming at the ends of periods of below-average rainfall.

Rainfall records, pertaining to the Lake Erie region directly, for the period 1838 through 1850 are from a gauge at Western Reserve University at Hudson, Ohio.

Rainfall data for the year 1859 is available, to date, only for Lake Huron. This has been corrected into an estimate for Lake Erie by using the rainfall ratio of the two lakes for the ten-year period 1871-1880 inclusive. The Lake Huron figure for 1859 and figures for Lake Erie in 1860-1867 inclusive are from an early report of the Chief of Engineers, U. S. Army Engineers. The reference to this source and to the others used are indicated with the data in Table VIII and given in full in "Literature Cited."

Precipitation data for the land area of Lakes Erie-St. Clair are given in Horton and Grunsky (1927). These data cover the years 1871 through 1922. Data of the U. S. Lake Survey, for the years 1900-1958, were very kindly provided by Mr. W. T. Laidly of the Survey. The overlap years (1900-1922) between Horton and Grunsky and the U. S. Lake Survey allow an assessment of the degree to which the inclusion of the Lake St. Clair basin by Horton and Grunsky may have interfered with the strict applicability of their data to the Lake Erie basin alone. Maximum variation between the two sets of data in the overlap years was 2.27 inches; minimum variation was 0.04 inches, with Horton and Grunsky being higher in both cases. The mean variation during the 23 years of overlap was 0.19 inch with Horton and Grunsky being the lower. The overlap years and the comparison of Horton and Grunsky to the Lake Survey are shown in Table VIII.

Total rainfall in the years for which there are figures has been summed and divided by the number of years for which there are figures. These figures, including the corrections, indicated above, yield a mean annual rainfall value of 35.55 inches for the period 1810-1958.

Years of above-average and below-average rainfall are given in the following table. All hyphenated figures are inclusive.

Above Average	Below Average
1810-1814	1815-1819
1819-1837	1838-1841
1842	1843
1848-1850	1860
1862	1863-1865
1866	1867
1873	1871-1872
1876	1874-1875
1878	1884
1880-1883	1886-1889

TABLE VIII

RAINFALL SINCE 1810

Philadelphia (Foster and Whitney, Pt. II, p. 337)

given: 1810-15* (5 years) 185.68 inches.
1815-19 (5 years) 151.14 inches.
1827-37 (11 years) 451.05 inches. Annual mean 41.00 inches.

*Taken as 1810-14, inclusive.

corrected: 1810-14, incl. 206.64 inches. Annual mean = 41.33 inches.
1815-19, incl. 168.20 inches. Annual mean = 33.64 inches.
1827-37, incl. 501.93 inches. Annual mean = 45.63 inches.

Marietta, Ohio (Foster and Whitney, Pt. II, p. 337)

1819-23 (5 years) 202.83 inches. Annual mean = 40.57 inches.
1828-32** (5 years) 228.17** inches. Annual mean = 45.63 inches.

**Omitted in computing mean of 1810-1958 period.

Hudson, Ohio (Foster and Whitney, Pt. II, p. 338)

mean of 1838, 1839, 1840	34.12 inches
1841	28.43 inches
1842	36.11 inches
1843	26.74 inches
1844	35.73 inches
mean of 1848, 1849, 1850	39.365 inches

Lake Huron (Rept. Chief of Engin. for 1868, Pt. II, p. 991)

given: 1859 27.90 inches

corrected: 1859 29.02 inches for Lake Erie

Lake Erie (Rept. Chief of Engin. for 1868, Pt. II, p. 991)

1860	31.29 inches
1861	35.58 inches
1862	36.58 inches
1863	31.69 inches
1864	34.00 inches
1865	32.67 inches
1866	38.15 inches
1867	28.61 inches

Lake Erie—St. Clair (Horton and Grunsky, 1927, Table 46, p. 112)

1871	30.9 inches
1872	29.9 inches
1873	38.8 inches
1874	29.2 inches
1875	33.6 inches
1876	39.5 inches
1877	35.3 inches
1878	45.3 inches
1879	35.3 inches
1880	40.5 inches
1881	41.2 inches
1882	37.1 inches
1883	38.4 inches
1884	32.3 inches
1885	37.4 inches
1886	32.9 inches
1887	31.6 inches
1888	29.9 inches
1889	29.5 inches
1890	41.9 inches
1891	32.3 inches
1892	38.4 inches
1893	36.0 inches
1894	30.5 inches
1895	28.5 inches
1896	34.7 inches
1897	31.9 inches
1898	35.3 inches
1899	29.2 inches

Year	Lake Erie—St. Clair	U. S. Lake Survey—Lake Erie	diff.	average (used in computing mean of 1810-1958)
1900	32.6 inches	32.53 inches	0.07	32.57
1901	30.5 inches	30.46 inches	0.04	30.48
1902	36.7 inches	36.49 inches	0.21	36.60
1903	36.4 inches	36.09 inches	0.31	36.25
1904	32.6 inches	34.16 inches	-1.56	33.38
1905	31.9 inches	33.58 inches	-1.68	32.74
1906	32.6 inches	33.62 inches	-1.02	33.11
1907	34.7 inches	36.21 inches	-1.51	35.46
1908	30.3 inches	30.91 inches	-0.61	30.61
1909	36.7 inches	38.00 inches	-1.30	37.35
1910	33.6 inches	33.38 inches	0.22	33.49
1911	36.0 inches	35.52 inches	0.48	35.76
1912	34.3 inches	34.66 inches	0.36	34.48
1913	38.1 inches	38.05 inches	0.05	38.08
1914	33.6 inches	33.23 inches	0.37	33.42
1915	34.7 inches	35.61 inches	-0.91	35.16
1916	34.0 inches	33.83 inches	0.17	33.92
1917	37.4 inches	35.13 inches	2.27	36.27
1918	31.9 inches	31.39 inches	0.51	31.65
1919	32.3 inches	32.67 inches	-0.37	32.49
1920	33.6 inches	31.94 inches	1.66	32.77
1921	34.3 inches	35.07 inches	-0.77	34.69
1922	30.9 inches	31.62 inches	-0.72	31.26
		Total	-4.45	
		Mean diff.	-0.19	

U. S. Lake Survey

1923	32.26 inches
1924	32.98 inches
1925	30.62 inches
1926	39.01 inches
1927	35.47 inches
1928	31.20 inches
1929	38.81 inches
1930	26.77 inches
1931	31.59 inches
1932	34.58 inches
1933	28.53 inches
1934	24.88 inches
1935	29.96 inches
1936	28.70 inches
1937	40.24 inches
1938	33.56 inches
1939	31.19 inches
1940	36.44 inches
1941	26.53 inches
1942	38.58 inches
1943	35.57 inches
1944	30.18 inches
1945	40.25 inches
1946	30.07 inches
1947	38.91 inches
1948	36.26 inches
1949	34.54 inches
1950	42.63 inches
1951	37.41 inches
1952	31.00 inches
1953	28.85 inches
1954	38.13 inches
1955	33.29 inches
1956	36.25 inches
1957	38.24 inches
1958	31.12 inches

Above Average	Below Average
1885	1891
1890	1894-1901
1892-1893	1904-1908
1902-1903	1910
1909	1912
1913	1914-1916
1917	1918-1925
1926	1928
1929	1930-1936
1937	1938-1939
1940	1941
1942	1944
1945	1946
1947-1948	1949
1950-1951	1952-1953
1954	1955
1956-1957	1958

Years not specifically listed in this table fell practically on the average.

PRE-1860 LAKE LEVELS OF LAKE ERIE

In our search for indices of past conditions of the aquatic environment we have come across a fairly substantial amount of data on lake levels of the years prior to 1860. While these old lake levels are at present of chiefly academic interest, they do have at least potential value in the search for indices inasmuch as they express the integrated effects of hydrology and progressive deforestation. The present hydrograph of lake levels put out by the U. S. Lake Survey, in extending back only through 1860, does not reach to the period when the Great Lakes watersheds were in essentially full-forest conditions: The present study allows the delineation of periods of high and low lake levels back to 1796. Accuracy of the lake height figures falls off as one goes into the period earlier than the high-water of 1838, but appears to be substantial back to the low-water of 1819-20. Earlier than the latter period, the records become predominantly the recollections of early settlers and are decreasingly accurate, but at least approximate figures can be deduced back to 1800-02. Prior to that time the data are merely qualitative.

Dominant high-waters are indicated in 1858-59, 1838, 1815-16, and 1800-02. Pronounced low-waters are indicated for the years 1819-20, 1809-10, and 1796. Also indicated quite clearly is a progressive downward trend in lake level from 1860-1796. The meaning of the latter is unknown, but it might be a reflection of the presence of the forest with its concomitant increased water loss in transpiration, interception, and retention.

The complete lake level data are given in Table IX; they have been obtained from the following sources (see Literature Cited for complete references): Houghton et al. (1848); U. S. Army Engineers (1870); Foster and Whitney (1851); Gilbert (1898); Houghton et al. (1839); Houghton et al. (1940); U. S. Army Engineers (1904).

LAKE ERIE WATER CHEMISTRY SINCE 1854

As a part of the program of assembling as complete as possible a background of information on the condition of the Lake Erie aquatic environment, search was made for chemical analyses of Lake Erie water. Suitable data of this type are not abundant but enough analyses were found to allow us to reconstruct the trend lines of chemical composition for the period 1854 to 1956. The data, together with indications of the source papers, are given in Table X.

The results clearly show a change in the chemical constituents of the lake water since 1854. They are summarized in about fifty-year intervals by the three major sets of analyses:

	1854	1906-07	1956
Alkalinity		98.*	90.
Silica	5.0	5.9	1.5
Iron	3.9	0.07	0.1
Calcium	20.	31.	36.
Magnesium		7.6	8.9
Sodium plus potassium	3.7	6.5	8.7
Carbonate		3.1	
Bicarbonate		114.	152.*
Sulphate	6.6	13.	23.
Nitrate		0.3	0.4
Chloride		8.7	20.
Total Solids	98.1	133.	171.

All analyses in parts per million
*Calculated by method of Palmer (1911).

It should be remarked in passing that none of these analyses appear to be suspect, except that for silica in the two sets of earlier determinations. Older silica values in these and other analyses are materially higher than are obtained by modern methods.

Other analyses in 1882, 1897, 1901, 1902, 1925, 1928, 1929, 1930, 1937 through 1948, 1948-49, and in 1950-52, while not complete analyses, do introduce

TABLE IX

MONTHLY MEAN LAKE LEVELS, LAKE ERIE, ABOVE MEAN TIDE AT NEW YORK, FEET. CLEVELAND GAUGE BACK THROUGH 1855.
Underlining indicates change of one digit.

Month	1859	1858	1857	1856	1855	1854	1853	1852	1851	1850	1849	1848	1847	1846	1845	1844	1843	1842
Jan	574.08	573.85	571.74	573.25	572.39				571.03					571.06				572.76
Feb	573.86	573.45	571.77	572.85	572.08				571.51					570.72				
Mar	574.27	573.48		572.52	572.14				572.12		572.03			570.64				
Apr	574.84	573.59		573.01	572.43				572.15					571.01				572.61
May	574.72	573.85	573.50	572.97	572.95				572.56		572.78	572.23	572.57	571.98	573.07	572.98	572.73	573.27
June	574.69	575.21	573.88	573.35	573.23				573.09	572.11				572.27				
July	574.75	575.16	573.97	573.38	573.73				573.16	572.73				572.22				
Aug	574.45	575.07	573.93	573.23	573.95	573.17			573.17					572.05	572.48			
Sept	573.85	574.51	573.68	572.98	573.30	572.84			572.86						572.16			
Oct	574.06	574.41	573.22	572.32	573.54	572.70			572.63			572,71	572.27,		571.93			
Nov	573.88	573.99	573.76	572.20	573.61	573.00				571.39					571.64			
Dec	573.68	574.09	573.76	572.49	573.89	572.42				571.49					571.31			

Month	1841	1840	1839	1838	1837	1836	1835	1834	1833	1832	1831	1830	1829	1828	1827	1826	1825	1824
Jan	572.39	570.37	571.51		572.02													
Feb	572.39																	
Mar	572.36											569.86						
Apr	572.75	571.79																
May	573.27	571.86	573.27	574.36														
June	573.01	571.94	573.60	575.03	572.53	572.47	572.34	572.59	571.94	572.28		571.86	571.86	571.86		572.28	571.11	
July	572.57	572.15	573.85	575.11														
Aug	572.07		573.90	574.55	573.22	572.72						571.72		571.72				
Sept	571.52	571.60	573.10	574.14	571.61		571.84											
Oct	570.64	571.49	574.07	573.75														
Nov	570.56	571.30	572.29	572.29														
Dec	571.68	571.07		573.15														

Month	1823	1822	1821	1820	1819	1818	1817	1816	1815	1814	1813	1812	1811	1810	1809	1808	1807	1806
Jan																		lake
Feb				568.44														low
Mar										568.25								
Apr													566.50					
May																		
June		570.11		569.02	569.78			571.86	570.11	570.75	568.25	567.25	566.33	566.00	566.00			
July					569.36				571.86									
Aug				570.07					573.11									
Sept																		
Oct																		
Nov																		
Dec							570.36											

Month	1800-1802	1798	1796	1702
Jan		lake	Lake very low,	Detroit
Feb		rising	possibly lowest	settled
Mar			of all; beach	by
Apr			never been so	French
May			broad and con-	
June	571.11		tinuous since.	
July			Settlers enter-	
Aug			ing Ohio drove	
Sept			teams on beach	
Oct			most of way	
Nov			from Buffalo to	
Dec			Cleveland.	

TABLE X

CHEMICAL ANALYSES, LAKE ERIE WATER, PPM

Analyses of 1854 and 1882 have been reduced from hypothetical combinations.

	Detroit River			Ashtabula	Off Erie	Buffalo	Off Ashtabula	Off Conneaut	Off Fairport	Cleveland			
	1854[a]	1882[a]	1897[a]	1901[b]	1901-03[c]	1906-07[d]	31 Jan. 1925[e]	31 Jan. 1925[e]	4 Feb. 1925[e]	1928[f]	1929[f]	1930[f]	1937[f]
Alkalinity					98.8	98.*	105	75 (?)	105.				
Silica	5.0	7.2				5.9							
Iron	3.9					0.07				0.61	0.64	0.79	0.37
Calcium	20.	26.4	23.			31.							
Magnesium		7.4				7.6						9.3	9.5
Sodium plus potassium	3.7					6.5							
Carbonate						3.1							
Bicarbonate				110.		114.							
Sulphate	6.6	4.6				13.							
Nitrate				0.1	0.09	0.3	0.06	0.21	0.04				
Chloride		7.5		5.1	6.4	8.7	15.	7.	42.				
Total solids	98.1	117.1	108.	159.	144.	133.	160.	140.	235.				

	Cleveland										Port Stanley, Ont.	Lorain	Erie
	1938[f]	1939[f]	1940[f]	1941[f]	1942[f]	1943[f]	1944[f]	1946[f]	1947[f]	1948[f]	1948-49[g]	1950-52[h]	1956[i]
Alkalinity												91.*	90.
Silica											1.3	1.9	1.5
Iron	0.44	0.42	0.34	0.29	0.42						0.02	0.04	0.1
Calcium											38.	36.	36.
Magnesium	9.2	9.1	8.6	8.7	8.8	8.7	9.1	8.9	8.5	8.6	7.7	8.5	8.9
Sodium plus potassium											9.2	9.5	8.7
Carbonate											0.4	8.0	
Bicarbonate											107.	113.	152.**
Sulphate											42.4	25.	23.
Nitrate											1.14	1.2	0.4
Chloride											17.8	18.	20.
Total solids											174.	165.	171.

*Calculated or back-calculated (**) by method of Palmer (1911).
[a]From U. S. Geol. Surv. Water-Supply Paper No. 31.
[b]Ashtabula, low pressure data, pp. 164-5 in Foulk (1925).
[c]From U. S. Geol. Surv. Water-Supply and Irrigation Paper No. 161.
[d]From U. S. Geol. Surv. Water-Supply Paper 236, also in U. S. Geol. Surv., Prof. Paper 135.
[e]Personal communication, U. S. Engineer Office, Buffalo, N. Y., to U. S. Fish and Wildlife Service, Ann Arbor. Ammonia fractions, nitrite, BOD also given. Single samples only.
[f]Data of the Division and Baldwin water plants at Cleveland, collected by the present contract. Yearly averages derived from monthly averages at the plants.
[g]Average of 12 monthly samples throughout the year, from Thomas (1954), pp. 26-29.
[h]Average of numerous samples throughout the year at the Lorain water plant, from Lake Erie Pollution Survey. Supplement (1953).
[i]From Ninetieth Annual Report of the City of Erie.

into the chemical history sufficient detail to indicate that nearly all the chemical parameters exhibited a notable depression in the period centered about 1897-1902. Since 1902 steady gains have been shown by total solids, calcium, sulphate, chloride, sodium plus potassium, and carbonate; in the same period decreases are shown by bicarbonate and silica; while magnesium, iron, and nitrate have shown little change.

Detailed analyses of numerous samples spread well throughout the year are available from Buffalo, N. Y. in 1906-07, Port Stanley, Ontario in 1948-49, Lorain, Ohio, in 1950-52 and from Erie, Pennsylvania in 1956; that from Port Stanley, Ontario is not quite comparable with the others as it involves the water of the northern part of the central basin. From Lorain 1950-52 was obtained the ratio of alkalinity to each of the other chemical constituents. These ratios were applied to the monthly alkalinity values obtained at the Lorain and Erie water plants to obtain approximate chemical compositions of the western and central basin waters during the period of record of these two plants. These monthly chemical estimates and annual means derived from them are given in Appendix I.

THE METROPOLITAN POPULATION INDEX

It is almost axiomatic that the quantities of foreign material entering a body of water are in proportion to the level of human population around that water body. The materials that enter Lake Erie as direct and indirect effects of man's presence can be represented in a rough and qualitative way by the human population in the metropolitan belt that surrounds the west and south sides of the lake.

To this end the sum of populations of Detroit, Toledo, Cleveland, Erie, and Buffalo have been taken as an index of the probable magnitude of man's total effects on Lake Erie. For comparative purposes the population of metropolitan Chicago is also included.

Census	Erie Index	Chicago
1950	3,778,927	3,620,962
1940	3,476,993	3,396,808
1930	3,448,852	3,376,438
1920	2,633,830	2,701,705
1910	1,685,166	2,185,283
1900	1,204,414	1,698,575
1890	844,961	1,099,850
1880	509,494	503,185
1870	337,350	298,977
1860	193,352	112,172
1850	90,001	29,963
1840	38,020	4,470
1830	13,431	-----
1820	4,758	-----

From these figures it is apparent that Lake Erie between 1820 and 1890 had a heavier population-pressure than the city of Chicago could have provided. From 1890 through 1920 Chicago contained somewhat more people than were located in the metropolitan belt of Lake Erie, but since 1930 Lake Erie has been subject to a larger metropolitan population than that of Chicago. When it is remembered that Lake Erie contains about 99 cubic miles of water while Lake Michigan contains 1120 cubic miles, it becomes reasonable to expect that the smaller lake may be reflecting in its chemistry the effects of human population-pressure. Except for the plant-nutrient chemicals (silica, nitrate, and possibly iron) and alkalinity, the chemical constituents of the lake have increased very significantly in the past century.

INDICATIONS OF BIOLOGICAL CHANGE

Several indications of biological change in Lake Erie can be found in the literature. The earliest found was reported by Mills (1882) and Smith (1882). Both of these authors mention a decrease in the numbers of the diatom *Stephanodiscus niagarae* in 1878; previously this form had been the most prevalent diatom in Lake Erie. The decline of this form, plus the discovery of *Actinocyclus niagarae* (Smith, 1878) and *Rhizosolenia gracilis* (Smith, 1882), fresh-water members of two predominantly marine genera of diatoms, represent changes in the phytoplankton of Lake Erie during the period 1877-1882. *Actinocyclus niagarae* later disappeared; it was last recorded in the winter of 1881-82 (Vorce, 1881). Snow (1903) stated that from 1889 to 1900 *Kirchneriella obesa* (Chlorophyceae) declined from one of the most common plankters to a form that was only occasionally recorded. During this same period, in 1899, *Oocystis borgei* (Chlorophyceae) first appeared and became a relatively abundant form. A year later, in 1900, this plankter had decreased and was found only in small numbers.

Hintz (1955) reported that *Cyclotella melosiroides* (alga), which was not present in Lake Erie prior to 1950, had increased by 1953 until it was a major form. He also recorded that Stephanodiscus sp. decreased during the period 1950-53.

In 1953, thermal stratification and resultant oxygen depletion in the Bass Islands region apparently resulted in heavy destruction of the may-fly *Hexagenia* (Britt, 1955a). In 1954 it appeared that the *Hexagenia* population would become reestablished (Britt, 1955b), but according to more recent studies it has apparently been unsuccessful (A. M. Beeton, U. S. Fish and Wildlife Service, personal communication). At present larvae of the midge, Chironomous, compose the bulk of the benthos in the Bass Islands region and the once prevalent *Hexagenia* are relatively scarce.

In 1955 a new diatom *Stephanodiscus hantzscii* appeared for the first time in the raw water of the South District Filtration Plant in Chicago, Illinois,

which obtains its water directly from Lake Michigan (J. R. Baylis, personal communication). This plankter had, by 1957, established itself as a major component of the phytoplankton, reaching population densities of 5,000 to 10,000 cells per 100 ml.

Further indications of biological change in Lake Erie can be found in the fluctuations of certain commercially valuable fish populations. Probably the most striking example of such fluctuations was the sudden decline of the cisco, Coregonus artedi, in 1925 (International Board of Inquiry for Great Lakes Fisheries, 1943). In 1924 the total production of this fishery, in both United States and Canadian waters, was 32,200,633 pounds; in 1925 it was 5,756,600 pounds, and by 1929 had declined to 488,874 pounds. It has never since approximated its former abundance. Intermittent records from 1879 to 1913, and yearly records from 1913 to the present indicate that prior to 1925 the catch had never fallen below 10,500,000 pounds, and in most years was in excess of 20,000,000 pounds. Such a sudden drop in numbers suggests the occurrence of a catastrophic event or a series of near-catastrophic events which would have acted to cause the death of possibly entire year classes. Analyses of the history of Lake Erie water chemistry indicate no such change or changes in the lake water; a perusal of the meteorology from 1880 to the present brings to light one particularly interesting point, namely, that March 1921 was the warmest March on record up to that time; in fact, only twice since that time has an equally high average temperature for that month been recorded, in 1946 and 1947.

John and Hasler (1956) have shown that a water temperature increase of 1°C during the last month of incubation of the cisco will advance the time of hatching seven days, and that ciscos hatched in water of temperatures between four and eleven degrees will be able to survive in the absence of food no longer than eighteen days. Since larval ciscos are zooplankton feeders, it is conceivable that an early hatch in 1921 could have preceded the time of the spring zooplankton pulse, resulting in the starvation of most of that year class. The loss of the reproductive potential of this year class could have, in turn, contributed to the decline of the fishery in 1925. Further work on this problem is necessary, and the ideas outlined here represent only preliminary considerations.

In summary, the literature indicates several periods of biological change:

1877-1882.	Change in phytoplankton in Lake Erie
1889-1900.	Change in phytoplankton in Lake Erie
1925.	Decline in cisco in Lake Erie
1950-1953.	Change in phytoplankton in Lake Erie
1953-1957.	Change in composition of bottom fauna in Bass Islands
1955-1957.	Change in phytoplankton in southern Lake Michigan.

SUMMARY OF MAJOR PAST EVENTS

The preceding sections have presented summaries of history of rainfall, lake levels, water chemistry, and biological changes in Lake Erie. These materials are given as they stand in our present state of knowledge. That they will be changed as additional information comes to light must be understood.

As a summary, Table XI has been prepared to point out the major events on record in the present status of the several categories. No attempt has been made to correlate simultaneous events on a cause and effect basis, and such is not implied in this summation. Meaningful correlations may well exist; they remain as priority topics for continued investigation.

CONCLUSION

The results and techniques presented in this report have come from the Lake Erie pilot study on the usefulness of the data being accumulated by municipal and industrial users of lake water. They show that these data have a very material potential in both understanding past events in the lake and in "watching" the lake for the development of trends in the future.

The pilot study, and the studies of past aquatic conditions that have accompanied it, have made available a substantial amount of new information and techniques that have promise of aiding in the understanding of past fluctuations in the commercial fisheries as well contributing to our understanding of the more academic problem of the eutrophication of lakes.

There are still a number of facets of the past conditions of the aquatic environment that have yet to be studied. Among these may be mentioned the assembly of a record of past unusually severe or unusually mild meteorological conditions and their probable effects on the lake, further search for biological indications of changing or changed conditions in the water, and the development of a set of criteria by which the data from representative water-user installations can be watched for the development of trends favorable or unfavorable for commercially important fish species.

Because the studies now completed and those outlined, in part, above are certain to provide a materially increased body of information pertinent to the understanding and management of the commercial fisheries, and because these studies may result in important break-throughs in the understanding of past fishery fluctuations, the investigators propose that Phase III of the contract outline (the collection of the useful data from collateral data sources) be abandoned in favor of a continuation of the types of study developed by the pilot program just completed.

TABLE XI

TENTATIVE MAJOR-EVENTS SUMMARY, 1800-1958

Year	Rainfall	Lake Level	Water Chemistry	Biology	Air Temperature
1801-02		low			
1809-10		low			
1810-14	high				
1815-16		high			
1815-19	low				
1819-20		low			
1819-37	high				
1838		high			
1838-41	low				
1840		low			
1842	high				
1843	low				
1846		low			
1848-50	high				
1854			Detroit River: Calcium low Total solids low		
1858-59		high			
1860	low				
1860-62		high			
1862	high				
1863-65	low				
1866	high				
1867	low				
1871-72	low				
1872		low			
1873	high				
1874-75	low				
1876	high	high			
1878	high			*Actinocyclus niagarae* discovered *Stephanodiscus niagarae* decreased	
1880	high				
1882			Detroit River: Calcium up Total solids up	*Rhizosolenia gracilis* discovered *Actinocyclus* disappeared	
1882-87		high			
1883	high				
1884	low				
1885	high				
1886-89	low				
1889-1900				*Kirchneriella obesa* declined	
1890		high			
1890-93	high				
1891	low				
1894-1901	low				
1895-96		low			
1897			Detroit River: Calcium low Total solids low		
1899				*Oocystis borgei* appeared	
1900				*Oocystis borgei* declined	
1901		low			
1902-03	high				
1904-08	low				
1909	high				
1910	low				
1911		low			
1912	low				
1913	high	high			
1914-16	low				
1915		low			
1917	high				
1918		low			
1918-25	low				
1921					Warmest March on record
1923		low			
1925				cisco decline	
1925-26		low	Ashtabula: Chlorides up		
1926	high				
1928	low				
1929	high				
1929-30		high			
1930-36	low				
1931-36		low			
1937	high				
1938-39	low				
1940	high				
1941	low				
1942	high				
1943-47		high			
1944	high				
1945	high				
1946	low				Warm March equals record
1947					Warm March equals record
1947-48	high				
1949	low				
1950-51	high			*Cyclotella melosiroides* appeared 1950 Stephanodiscus sp. declined 1950-53	
1952		high			
1952-53	low			*Cyclotella melosiroides* a major form 1953	
1953				*Hexagenia* decline	
1954	high				
1955	low			*Stephanodiscus hantzscii* appeared in southern L. Michigan	
1956			Erie, Pa.: Nitrate up Alkalinity down Chlorides up Total solids up		
1956-57	high				
1958	low				

A further factor in making this recommendation is the demonstration, in the present report, that not all onshore data sources are representative stations. Before the useful data could be collected from all sources around the several lakes, it would be necessary to eliminate all the unrepresentative stations.

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APPENDIX I

VALUES BASED ON TOTAL ALKALINITY

Part 1. Station at Lorain, Ohio

Year 1910

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.	Ratio*
Temp.(Avon)														
Temp.(Lorain)														
Total solids	121	129	123	147	154	172	174	179	170	148	168	159	154	1.81
Nitrate	.88	.94	.90	1.07	1.12	1.25	1.27	1.31	1.24	1.08	1.23	1.16	1.12	.0132
Fluoride	.07	.08	.07	.09	.09	.10	.11	.11	.10	.09	.10	.10	.09	.0011
Chloride	13.3	14.1	13.5	16.0	16.8	18.8	19.0	19.6	18.6	16.2	18.4	17.4	16.8	.198
Sulphate	18.4	19.5	18.7	22.3	23.4	26.1	26.4	27.2	25.9	22.5	25.6	24.2	23.4	.275
Bicarbonate	83	88	84	100	105	118	119	123	117	102	115	109	105	1.24
Sodium plus potassium	7.0	7.4	7.1	8.4	8.8	9.9	10.0	10.3	9.7	8.5	9.7	9.2	8.8	.104
Magnesium	6.2	6.6	6.3	7.5	7.9	8.8	8.9	9.2	8.7	7.6	8.6	8.2	7.9	.093
Calcium	26.5	28.0	26.9	32.0	33.6	37.5	37.9	39.1	37.1	32.4	36.7	34.8	33.5	.395
Iron	.03	.03	.03	.03	.03	.04	.04	.04	.04	.03	.04	.04	.03	.0004
Silica	1.4	1.5	1.4	1.7	1.8	2.0	2.0	2.1	2.0	1.7	2.0	1.8	1.8	.021
Alkalinity	67	71	68	81	85	95	96	99	94	82	93	88	84.9	1.0

*The "ratio" values indicated are the ratio of the parameter in question to alkalinity, i.e., "ratio" = parameter/alkalinity. These values apply to years 1910-1957, pages 62-109.

Year 1911

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp. (Avon)													
Temp. (Lorain)													
Total solids	138	150	163	159	167	168	170	168	150	145	147	143	156
Nitrate	1.00	1.10	1.19	1.16	1.21	1.23	1.24	1.23	1.10	1.06	1.07	1.04	1.13
Fluoride	.08	.09	.10	.10	.10	.10	.10	.10	.09	.09	.09	.09	.09
Chloride	15.0	16.4	17.8	17.4	18.2	18.4	18.6	18.4	16.4	15.8	16.0	15.6	17.0
Sulphate	20.9	22.8	24.7	24.2	25.3	25.6	25.9	25.6	22.8	22.0	22.3	21.7	23.6
Bicarbonate	94	103	112	109	114	115	117	115	103	99	100	98	107
Sodium plus potassium	7.9	8.6	9.4	9.2	9.6	9.7	9.8	9.7	8.6	8.3	8.4	8.2	8.9
Magnesium	7.1	7.7	8.4	8.2	8.6	8.6	8.7	8.6	7.7	7.4	7.5	7.3	8.0
Calcium	30.0	32.8	35.5	34.8	36.3	36.7	37.1	36.7	32.8	31.6	32.0	31.2	34.0
Iron	.03	.03	.04	.04	.04	.04	.04	.04	.03	.03	.03	.03	.03
Silica	1.6	1.7	1.9	1.8	1.9	2.0	2.0	2.0	1.7	1.7	1.7	1.7	1.8
Alkalinity	76	83	90	88	92	93	94	93	83	80	81	79	86.0

Year 1912

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp. (Avon)													
Temp. (Lorain)													
Total solids	145	130	110	138	152	168	170	172	170	172	172	172	156
Nitrate	1.06	.95	.81	1.00	1.11	1.23	1.24	1.25	1.24	1.25	1.25	1.25	1.13
Fluoride	.09	.08	.07	.08	.09	.10	.10	.10	.10	.10	.10	.10	.09
Chloride	15.8	14.3	12.1	15.0	16.6	18.4	18.6	18.8	18.6	18.8	18.8	18.8	17.0
Sulphate	22.0	19.8	16.8	20.9	23.1	25.6	25.9	26.1	25.9	26.1	26.1	26.1	23.7
Bicarbonate	99	89	76	94	104	115	117	118	117	118	118	118	107
Sodium plus potassium	8.3	7.5	6.3	7.9	8.7	9.7	9.8	9.9	9.8	9.9	9.9	9.9	9.0
Magnesium	7.4	6.7	5.7	7.1	7.8	8.6	8.7	8.8	8.7	8.8	8.8	8.8	8.0
Calcium	31.6	28.4	24.1	30.0	33.2	36.7	37.1	37.5	37.1	37.5	37.5	37.5	34.0
Iron	.03	.03	.02	.03	.03	.04	.04	.04	.04	.04	.04	.04	.03
Silica	1.7	1.5	1.3	1.6	1.8	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.8
Alkalinity	80	72	61	76	84	93	94	95	94	95	95	95	86.2

Year 1913

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp. (Avon)													
Temp. (Lorain)													
Total solids	154	172	148	156	163	167	170	177	177	174	170	168	166
Nitrate	1.12	1.25	1.08	1.14	1.19	1.21	1.24	1.29	1.29	1.27	1.24	1.23	1.21
Fluoride	.09	.10	.09	.09	.10	.10	.10	.11	.11	.11	.10	.10	.10
Chloride	16.8	18.8	16.2	17.0	17.8	18.2	18.6	19.4	19.4	19.0	18.6	18.4	18.2
Sulphate	23.4	26.1	22.5	23.7	24.7	25.3	25.9	26.9	26.9	26.4	25.9	25.6	25.3
Bicarbonate	105	118	102	107	112	114	117	122	122	119	117	115	114
Sodium plus potassium	8.8	9.9	8.5	8.9	9.4	9.6	9.8	10.2	10.2	10.0	9.8	9.7	9.6
Magnesium	7.9	8.8	7.6	8.0	8.4	8.6	8.7	9.1	9.1	8.9	8.7	8.6	8.5
Calcium	33.6	37.5	32.4	34.0	35.5	36.3	37.1	38.7	38.7	37.9	37.1	36.7	36.3
Iron	.03	.04	.03	.03	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	1.8	2.0	1.7	1.8	1.9	1.9	2.0	2.1	2.1	2.0	2.0	2.0	1.9
Alkalinity	85	95	82	86	90	92	94	98	98	96	94	93	91.9

Year 1914

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)													
Temp.(Lorain)													
Total solids	170	168	165	167	157	172	177	179	177	176	176	174	172
Nitrate	1.24	1.23	1.20	1.21	1.15	1.25	1.29	1.31	1.29	1.28	1.28	1.27	1.25
Fluoride	.10	.10	.10	.10	.10	.10	.11	.11	.11	.11	.11	.11	.10
Chloride	18.6	18.4	18.0	18.2	17.2	18.8	19.4	19.6	19.4	19.2	19.2	19.0	18.8
Sulphate	25.9	25.6	25.0	25.3	23.9	26.1	26.9	27.2	26.9	26.7	26.7	26.4	26.0
Bicarbonate	117	115	113	114	108	118	122	123	122	120	120	119	118
Sodium plus potassium	9.8	9.7	9.5	9.6	9.0	9.9	10.2	10.3	10.2	10.1	10.1	10.0	9.9
Magnesium	8.7	8.6	8.5	8.6	8.1	8.8	9.1	9.2	9.1	9.0	9.0	8.9	8.8
Calcium	37.1	36.7	35.9	36.3	34.4	37.5	38.7	39.1	38.7	38.3	38.3	37.9	37.4
Iron	.04	.04	.04	.04	.03	.04	.04	.04	.04	.04	.04	.04	.04
Silica	2.0	2.0	1.9	1.9	1.8	2.0	2.1	2.1	2.1	2.0	2.0	2.0	2.0
Alkalinity	94	93	91	92	87	95	98	99	98	97	97	96	94.8

Year 1915

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)													
Temp.(Lorain)													
Total solids	172	163	170	172	170	176	172	174	176	176	176	176	173
Nitrate	1.25	1.19	1.24	1.25	1.24	1.28	1.25	1.27	1.28	1.28	1.28	1.28	1.26
Fluoride	.10	.10	.10	.10	.10	.11	.10	.11	.11	.11	.11	.11	.10
Chloride	18.8	17.8	18.6	18.8	18.6	19.2	18.8	19.0	19.2	19.2	19.2	19.2	18.9
Sulphate	26.1	24.7	25.9	26.1	25.9	26.7	26.1	26.4	26.7	26.7	26.7	26.7	26.2
Bicarbonate	118	112	117	118	117	120	118	119	120	120	120	120	118
Sodium plus potassium	9.9	9.4	9.8	9.9	9.8	10.1	9.9	10.0	10.1	10.1	10.1	10.1	9.9
Magnesium	8.8	8.4	8.7	8.8	8.7	8.7	8.8	8.9	9.0	9.0	9.0	9.0	8.8
Calcium	37.5	35.5	37.1	37.5	37.1	38.3	37.5	37.9	38.3	38.3	38.3	38.3	37.6
Iron	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	2.0	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Alkalinity	95	90	94	95	94	97	95	96	97	97	97	97	95.3

Year 1916

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp. (Avon)													
Temp. (Lorain)													
Total solids	161	172	176	174	174	179	181	181	179	176	174	172	175
Nitrate	1.17	1.25	1.28	1.27	1.27	1.31	1.32	1.32	1.31	1.28	1.27	1.25	1.28
Fluoride	.10	.10	.11	.11	.11	.11	.11	.11	.11	.11	.11	.10	.11
Chloride	17.6	18.8	19.2	19.0	19.0	19.6	19.8	19.8	19.6	19.2	19.0	18.8	19.1
Sulphate	24.5	26.1	26.7	26.4	26.4	27.2	27.5	27.5	27.2	26.7	26.4	26.1	26.6
Bicarbonate	110	118	120	119	119	123	124	124	123	120	119	118	120
Sodium plus potassium	9.3	9.9	10.1	10.0	10.0	10.3	10.4	10.4	10.3	10.1	10.0	9.9	10.1
Magnesium	8.3	8.8	9.0	8.9	8.9	9.2	9.3	9.3	9.2	9.0	8.9	8.8	9.0
Calcium	35.2	37.5	38.3	37.9	37.9	39.1	39.5	39.5	39.1	38.3	37.9	37.5	38.1
Iron	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	1.9	2.0	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.0	2.0	2.0	2.0
Alkalinity	89	95	97	96	96	99	100	100	99	97	96	95	96.6

Year 1917

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)													
Temp.(Lorain)							22	23	20	12	7		
Total solids	174	177	170	167	170	177	183	185	186	177	172	170	176
Nitrate	1.27	1.29	1.24	1.21	1.24	1.29	1.33	1.35	1.36	1.29	1.25	1.24	1.28
Fluoride	.11	.11	.10	.10	.10	.11	.11	.11	.11	.11	.10	.10	.11
Chloride	19.0	19.4	18.6	18.2	18.6	19.4	20.0	20.2	20.4	19.4	18.8	18.6	19.2
Sulphate	26.4	26.9	25.9	25.3	25.9	26.9	27.8	28.0	28.3	26.9	26.1	25.9	26.7
Bicarbonate	119	122	117	114	117	122	125	126	128	122	118	117	121
Sodium plus potassium	10.0	10.2	9.8	9.6	9.8	10.2	10.5	10.6	10.7	10.2	9.9	9.8	10.1
Magnesium	8.9	9.1	8.7	8.6	8.7	9.1	9.4	9.5	9.6	9.1	8.8	8.7	9.0
Calcium	37.9	38.7	37.1	36.3	37.1	38.7	39.9	40.3	40.7	38.7	37.5	37.1	38.3
Iron	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	2.0	2.1	2.0	1.9	2.0	2.1	2.1	2.1	2.2	2.1	2.0	2.0	2.0
Alkalinity	96	98	94	92	94	98	101	102	103	98	95	94	97.1

Year 1918

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)													
Temp.(Lorain)	2		4	7	16	21	21	23	19	13	6	4	12.4
Total solids	176	138	159	165	167	163	165	174	174	176	176	172	167
Nitrate	1.28	1.00	1.16	1.20	1.21	1.19	1.20	1.27	1.27	1.28	1.28	1.25	1.22
Fluoride	.11	.08	.10	.10	.10	.10	.10	.11	.11	.11	.11	.10	.10
Chloride	19.2	15.0	17.4	18.0	18.2	17.8	18.0	19.0	19.0	19.2	19.2	18.8	18.2
Sulphate	26.7	20.9	24.2	25.0	25.3	24.7	25.0	26.4	26.4	26.7	26.7	26.1	25.3
Bicarbonate	120	94	109	113	114	112	113	119	119	120	120	118	114
Sodium plus potassium	10.1	7.9	9.2	9.5	9.6	9.4	9.5	10.0	10.0	10.1	10.1	9.9	9.6
Magnesium	9.0	7.1	8.2	8.5	8.6	8.4	8.5	8.9	8.9	9.0	9.0	8.8	8.6
Calcium	38.3	30.0	34.8	35.9	36.3	35.5	35.9	37.9	37.9	38.3	38.3	37.5	36.4
Iron	.04	.03	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	2.0	1.6	1.8	1.9	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.0	1.9
Alkalinity	97	76	88	91	92	90	91	96	96	97	97	95	92.2

Year 1919

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)													
Temp.(Lorain)	3	2	3.6	5.5	12	18	23	23	21	16	10	2.5	11.6
Total solids	174	176	170	176	177	181	188	177	192	179	172	170	178
Nitrate	1.27	1.28	1.24	1.28	1.29	1.32	1.37	1.29	1.40	1.31	1.25	1.24	1.29
Fluoride	.11	.11	.10	.11	.11	.11	.11	.11	.12	.11	.10	.10	.11
Chloride	19.0	19.2	18.6	19.2	19.4	19.8	20.6	19.4	21.0	19.6	18.8	18.6	19.4
Sulphate	26.4	26.7	25.9	26.7	26.9	27.5	28.6	26.9	29.2	27.2	26.1	25.9	27.0
Bicarbonate	119	120	117	120	122	124	129	122	131	123	118	117	122
Sodium plus potassium	10.0	10.1	9.8	10.1	10.2	10.4	10.8	10.2	11.0	10.3	9.9	9.8	10.2
Magnesium	8.9	9.0	8.7	9.0	9.1	9.3	9.7	9.1	9.9	9.2	8.8	8.7	9.1
Calcium	37.9	38.3	37.1	38.3	38.7	39.5	41.1	38.7	41.9	39.1	37.5	37.1	38.8
Iron	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	2.0	2.0	2.0	2.0	2.1	2.1	2.2	2.1	2.2	2.1	2.0	2.0	2.1
Alkalinity	96	97	94	97	98	100	104	98	106	99	95	94	98.2

Year 1920

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)													
Temp.(Lorain)	1	1	2	6	11	17	21	21	21	16	8	4	10.8
Total solids	174	174	152	148	154	156	174	176	174	174	170	177	167
Nitrate	1.27	1.27	1.11	1.08	1.12	1.14	1.27	1.28	1.27	1.27	1.24	1.29	1.22
Fluoride	.11	.11	.09	.09	.09	.09	.11	.11	.11	.11	.10	.11	.10
Chloride	19.0	19.0	16.6	16.2	16.8	17.0	19.0	19.2	19.0	19.0	18.6	19.4	18.2
Sulphate	26.4	26.4	23.1	22.5	23.4	23.7	26.4	26.7	26.4	26.4	25.9	26.9	25.4
Bicarbonate	119	119	104	102	105	107	119	120	119	119	117	122	114
Sodium plus potassium	10.0	10.0	8.7	8.5	8.8	8.9	10.0	10.1	10.0	10.0	9.8	10.2	9.6
Magnesium	8.9	8.9	7.8	7.6	7.9	8.0	8.9	9.0	8.9	8.9	8.7	9.1	8.6
Calcium	37.9	37.9	33.2	32.4	33.6	34.0	37.9	38.3	37.9	37.9	37.1	38.7	36.4
Iron	.04	.04	.03	.03	.03	.03	.04	.04	.04	.04	.04	.04	.04
Silica	2.0	2.0	1.8	1.7	1.8	1.8	2.0	2.0	2.0	2.0	2.0	2.1	1.9
Alkalinity	96	96	84	82	85	86	96	97	96	96	94	98	92

Year 1921

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp. (Avon)													
Temp. (Lorain)	1	1	6	9	12	20	25	23	21	16	9	4	12.3
Total solids	181	161	161	168	174	174	177	188	185	183	167	172	174
Nitrate	1.32	1.17	1.17	1.23	1.27	1.27	1.29	1.37	1.35	1.33	1.21	1.25	1.27
Fluoride	.11	.10	.10	.10	.11	.11	.11	.11	.11	.11	.10	.10	.11
Chloride	19.8	17.6	17.6	18.4	19.0	19.0	19.4	20.6	20.2	20.0	18.2	18.8	19.0
Sulphate	27.5	24.5	24.5	25.6	26.4	26.4	26.9	28.6	28.0	27.8	25.3	26.1	26.5
Bicarbonate	124	110	110	115	119	119	122	129	126	125	114	118	119
Sodium plus potassium	10.4	9.3	9.3	9.7	10.0	10.0	10.2	10.8	10.6	10.5	9.6	9.9	10.0
Magnesium	9.3	8.3	8.3	8.6	8.9	8.9	9.1	9.7	9.5	9.4	8.6	8.8	8.9
Calcium	39.5	35.2	35.2	36.7	37.9	37.9	38.7	41.1	40.3	39.9	36.3	37.5	38.0
Iron	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	2.1	1.9	1.9	2.0	2.0	2.0	2.1	2.2	2.1	2.1	1.9	2.0	2.0
Alkalinity	100	89	89	93	96	96	98	104	102	101	92	95	96.3

Year 1922

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp. (Avon)													
Temp. (Lorain)	1		3	7	12	19	24	23	21	15	10	4	12.6
Total solids	176	170	167	157	170	176	174	176	179	177	179	179	173
Nitrate	1.28	1.24	1.21	1.15	1.24	1.28	1.27	1.28	1.31	1.29	1.31	1.31	1.26
Fluoride	.11	.10	.10	.10	.10	.11	.11	.11	.11	.11	.11	.11	.11
Chloride	19.2	18.6	18.2	17.2	18.6	19.2	19.0	19.2	19.6	19.4	19.6	19.6	19.0
Sulphate	26.7	25.9	25.3	23.9	25.9	26.7	26.4	26.7	27.2	26.9	27.2	27.2	26.3
Bicarbonate	120	117	114	108	117	120	119	120	123	122	123	123	119
Sodium plus potassium	10.1	9.8	9.6	9.0	9.8	9.0	10.0	10.1	10.3	10.2	10.3	10.3	9.9
Magnesium	9.0	8.7	8.6	8.1	8.7	9.0	8.9	9.0	9.2	9.1	9.2	9.2	8.9
Calcium	38.3	37.1	36.3	34.4	37.1	38.3	37.9	38.3	39.1	38.7	39.1	39.1	37.8
Iron	.04	.04	.04	.03	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	2.0	2.0	1.9	1.8	2.0	2.0	2.0	2.0	2.1	2.1	2.1	2.1	2.0
Alkalinity	97	94	92	87	94	97	96	97	99	98	99	99	95.8

Year 1923

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)													
Temp.(Lorain)	4	2	2	7	10	17	24	22	20	15	9	5	11.4
Total solids	168	176	170	176	172	179	183	188	190	188	183	170	179
Nitrate	1.23	1.28	1.24	1.28	1.25	1.31	1.33	1.37	1.39	1.37	1.33	1.24	1.30
Fluoride	.10	.11	.10	.11	.10	.11	.11	.11	.12	.11	.11	.10	.11
Chloride	18.4	19.2	18.6	19.2	18.8	19.6	20.0	20.6	20.8	20.6	20.0	18.6	19.5
Sulphate	25.6	26.7	25.9	26.7	26.1	27.2	27.8	28.6	28.9	28.6	27.8	25.9	27.2
Bicarbonate	115	120	117	120	118	123	125	129	130	129	125	117	122
Sodium plus potassium	9.7	10.1	9.8	10.1	9.9	10.3	10.5	10.8	10.9	10.8	10.5	9.8	10.3
Magnesium	8.6	9.0	8.7	9.0	8.8	9.2	9.4	9.7	9.8	9.7	9.4	8.7	9.2
Calcium	36.7	38.3	37.1	38.3	37.5	39.1	39.9	41.1	41.5	41.1	39.9	37.1	39.0
Iron	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	2.0	2.0	2.0	2.0	2.0	2.1	2.1	2.2	2.2	2.2	2.1	2.0	2.1
Alkalinity	93	97	94	97	95	99	101	104	105	104	101	94	98.7

Year 1924

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)													
Temp.(Lorain)	2		2	6	12	17	22	22	19	15	9	3	11.7
Total solids	176	177	177	172	172	177	176	183	188	186	185	183	179
Nitrate	1.28	1.29	1.29	1.25	1.25	1.29	1.28	1.33	1.37	1.36	1.35	1.33	1.31
Fluoride	.11	.11	.11	.10	.10	.11	.11	.11	.11	.11	.11	.11	.11
Chloride	19.2	19.4	19.4	18.8	18.8	19.4	19.2	20.0	20.6	20.4	20.2	20.0	19.6
Sulphate	26.7	26.9	26.9	26.1	26.1	26.9	26.7	27.8	28.6	28.3	28.0	27.8	27.2
Bicarbonate	120	122	122	118	118	122	120	125	129	128	126	125	123
Sodium plus potassium	10.1	10.2	10.2	9.9	9.9	10.2	10.1	10.5	10.9	10.7	10.6	10.5	10.3
Magnesium	9.0	9.1	9.1	8.8	8.8	9.1	9.0	9.4	9.7	9.6	9.5	9.4	9.2
Calcium	38.3	38.7	38.7	37.5	37.5	38.7	38.3	39.9	41.1	40.7	40.3	39.9	39.1
Iron	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	2.0	2.1	2.1	2.0	2.0	2.1	2.0	2.1	2.2	2.2	2.1	2.1	2.1
Alkalinity	97	98	98	95	95	98	97	101	104	103	102	101	99.1

Year 1925

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp. (Avon)													
Temp. (Lorain)	1	1	4	9	13	19	23	24	22		8	3	11.5
Total solids	192	181	179	181	183	188	188	185	185	183	179	185	184
Nitrate	1.40	1.32	1.31	1.32	1.33	1.37	1.37	1.35	1.35	1.33	1.31	1.35	1.34
Fluoride	.12	.11	.11	.11	.11	.11	.11	.11	.11	.11	.11	.11	.11
Chloride	21.0	19.8	19.6	19.8	20.0	20.6	20.6	20.2	20.2	20.0	19.6	20.2	20.1
Sulphate	29.2	27.5	27.2	27.5	27.8	28.6	28.6	28.0	28.0	27.8	27.2	28.0	28.0
Bicarbonate	131	124	123	124	125	129	129	126	126	125	123	126	126
Sodium plus potassium	11.0	10.4	10.3	10.4	10.5	10.8	10.8	10.6	10.6	10.5	10.3	10.6	10.6
Magnesium	9.9	9.3	9.2	9.3	9.4	9.7	9.7	9.5	9.5	9.4	9.2	9.5	9.5
Calcium	41.9	39.5	39.1	39.5	39.9	41.1	41.1	40.3	40.3	39.9	39.1	40.3	40.2
Iron	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	2.2	2.1	2.1	2.1	2.1	2.2	2.2	2.1	2.1	2.1	2.1	2.1	2.1
Alkalinity	106	100	99	100	101	104	104	102	102	101	99	102	101.7

Year 1926

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)													
Temp.(Lorain)	1	1	3	6	13	20	25	25	22	15	9	2	11.8
Total solids	190	190	186	179	186	185	185	188	181	174	177	181	184
Nitrate	1.39	1.39	1.36	1.31	1.36	1.35	1.35	1.37	1.32	1.27	1.29	1.32	1.34
Fluoride	.12	.12	.11	.11	.11	.11	.11	.11	.11	.11	.11	.11	.11
Chloride	20.8	20.8	20.4	19.6	20.4	20.2	20.2	20.6	19.8	19.0	19.4	19.8	20.1
Sulphate	28.9	28.9	28.3	27.2	28.9	28.0	28.0	28.6	27.5	26.4	26.9	27.5	27.9
Bicarbonate	130	130	128	123	128	126	126	129	124	119	122	124	126
Sodium plus potassium	10.9	10.9	10.7	10.3	10.7	10.6	10.6	10.8	10.4	10.0	10.2	10.4	10.5
Magnesium	9.8	9.8	9.6	9.2	9.6	9.5	9.5	9.7	9.3	8.9	9.1	9.3	9.4
Calcium	41.5	41.5	40.7	39.1	40.7	40.3	40.3	41.1	39.5	37.9	38.7	39.5	40.1
Iron	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	2.2	2.2	2.2	2.1	2.2	2.1	2.1	2.2	2.1	2.0	2.1	2.1	2.1
Alkalinity	105	105	103	99	103	102	102	104	100	96	98	100	101.4

Year 1927

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	1.1	1.4	3.3	8.6	13.5	17.5	22.6	21.9	20.3	15.3	8.8	2.5	11.4
Temp.(Lorain)	1	2	4	9	12	19	23	22	20	15	10	3	11.7
Total solids	167	170	172	179	179	183	181	181	177	179	179	168	176
Nitrate	1.21	1.24	1.25	1.31	1.31	1.33	1.32	1.32	1.29	1.31	1.31	1.23	1.29
Fluoride	.10	.10	.10	.11	.11	.11	.11	.11	.11	.11	.11	.10	.11
Chloride	18.2	18.6	18.8	19.6	19.6	20.0	19.8	19.8	19.4	19.6	19.6	18.4	19.3
Sulphate	25.3	25.9	26.1	27.2	27.2	27.8	27.5	27.5	26.9	27.2	27.2	25.6	26.8
Bicarbonate	114	117	118	123	123	125	124	124	122	123	123	115	121
Sodium plus potassium	9.6	9.8	9.9	10.3	10.3	10.5	10.4	10.4	10.2	10.3	10.3	9.7	10.1
Magnesium	8.6	8.7	8.8	9.2	9.2	9.4	9.3	9.3	9.1	9.2	9.2	8.6	9.1
Calcium	36.3	37.1	37.5	39.1	39.1	39.9	39.5	39.5	38.7	39.1	39.1	36.7	38.5
Iron	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	1.9	2.0	2.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.0	2.1
Alkalinity	92	94	95	99	99	101	100	100	98	99	99	93	97.4

Year 1928

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	1.4	1.0	1.9	6.7	12.7	17.3	23.6	24.3	18.6	14.6	7.8	2.8	11.1
Temp.(Lorain)		1	3	5	9	16	23	24	22	14	9	3	11.7
Total solids	177	176	179	172	177	179	181	179	181	185	183	177	179
Nitrate	1.29	1.28	1.31	1.25	1.29	1.31	1.32	1.31	1.32	1.35	1.33	1.29	1.30
Fluoride	.11	.11	.11	.10	.11	.11	.11	.11	.11	.11	.11	.11	.11
Chloride	19.4	19.2	19.6	18.8	19.4	19.6	19.8	19.6	19.8	20.2	20.0	19.4	19.6
Sulphate	26.9	26.7	27.2	26.1	26.9	27.2	27.5	27.2	27.5	28.0	27.8	26.9	27.2
Bicarbonate	122	120	123	118	122	123	124	123	124	126	125	122	123
Sodium plus potassium	10.2	10.1	10.3	9.9	10.2	10.3	10.4	10.3	10.4	10.6	10.5	10.2	10.3
Magnesium	9.1	9.0	9.2	8.8	9.1	9.2	9.3	9.2	9.3	9.5	9.4	9.1	9.2
Calcium	38.7	38.3	39.1	37.5	38.7	39.1	39.5	39.1	39.5	40.3	39.9	38.7	39.0
Iron	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	2.1	2.0	2.1	2.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Alkalinity	98	97	99	95	98	99	100	99	100	102	101	98	98.8

Year 1929

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	1.1	1.1	4.5	9.3	12.7	19.6	22.9	22.3	19.8	13.3	7.4	1.6	11.3
Temp.(Lorain)	1	1	4	9	11	19	23		21	15	8	1	9.4
Total solids	165	167	161	157	170	174	181	185	186	181	174	172	173
Nitrate	1.20	1.21	1.17	1.15	1.24	1.27	1.32	1.35	1.36	1.32	1.27	1.25	1.26
Fluoride	.10	.10	.10	.10	.10	.11	.11	.11	.11	.11	.11	.10	.10
Chloride	18.0	18.2	17.6	17.2	18.6	19.0	19.8	20.2	20.4	19.8	19.0	18.8	18.9
Sulphate	25.0	25.3	24.5	23.9	25.9	26.4	27.5	28.0	28.3	27.5	26.4	26.1	26.2
Bicarbonate	113	114	110	108	117	119	124	126	128	124	119	118	118
Sodium plus potassium	9.5	9.6	9.3	9.0	9.8	10.0	10.4	10.6	10.7	10.4	10.0	9.9	9.9
Magnesium	8.5	8.6	8.3	8.1	8.7	8.9	9.3	9.5	9.6	9.3	8.9	8.8	8.9
Calcium	35.9	36.3	35.2	34.4	37.1	37.9	39.5	40.3	40.7	39.5	37.9	37.5	37.7
Iron	.04	.04	.04	.03	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	1.9	1.9	1.9	1.8	2.0	2.0	2.1	2.1	2.2	2.1	2.0	2.0	2.0
Alkalinity	91	92	89	87	94	96	100	102	103	100	96	95	95.4

Year 1930

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	1.8	2.6	2.9	7.3	13.8	19.5	23.2	23.6	20.9	13.8	7.2	2.2	11.6
Temp.(Lorain)													
Total solids	159	174	163	168	177	182	181	181	181	183	177	176	175
Nitrate	1.16	1.27	1.19	1.23	1.29	1.33	1.32	1.32	1.32	1.33	1.29	1.28	1.28
Fluoride	.10	.11	.10	.10	.11	.11	.11	.11	.11	.11	.11	.11	.11
Chloride	17.4	19.0	17.8	18.4	19.4	20.0	19.8	19.8	19.8	20.0	19.4	19.2	19.2
Sulphate	24.2	26.4	24.7	25.6	26.9	27.8	27.5	27.5	27.5	27.8	26.9	26.7	26.6
Bicarbonate	109	119	112	115	122	125	124	124	124	125	122	120	120
Sodium plus potassium	9.2	10.0	9.4	9.7	10.2	10.5	10.4	10.4	10.4	10.5	10.2	10.1	10.1
Magnesium	8.2	8.9	8.4	8.6	9.1	9.4	9.3	9.3	9.3	9.4	9.1	9.0	9.0
Calcium	34.4	37.9	35.5	36.7	38.7	39.9	39.5	39.5	39.5	39.9	38.7	38.3	38.2
Iron	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	1.8	2.0	1.9	2.0	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.0	2.0
Alkalinity	88	96	90	93	98	101	100	100	100	101	98	97	96.8

Year 1931

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	.9	1.6	2.4	8.1	12.7	19.2	25.8	23.6	22.3	16.1	10.5	5.6	12.4
Temp.(Lorain)													
Total solids	172	165	163	163	170	172	172	174	172	176	174	174	170.6
Nitrate	1.25	1.20	1.19	1.19	1.24	1.25	1.25	1.27	1.25	1.28	1.27	1.27	1.24
Fluoride	.10	.10	.10	.10	.10	.10	.10	.11	.10	.11	.11	.11	.10
Chloride	18.8	18.0	17.8	17.8	18.6	18.8	18.8	19.0	18.8	19.2	19.0	19.0	18.6
Sulphate	26.1	25.0	24.7	24.7	25.9	26.1	26.1	26.4	26.1	26.7	26.4	26.4	25.9
Bicarbonate	118	113	112	112	117	118	118	119	118	120	119	119	117
Sodium plus potassium	9.9	9.5	9.4	9.4	9.8	9.9	9.9	10.0	9.9	10.1	10.0	10.0	9.8
Magnesium	8.8	8.5	8.4	8.4	8.7	8.8	8.8	8.9	8.8	9.0	8.9	8.9	8.7
Calcium	37.5	35.9	35.5	35.5	37.1	37.5	37.5	37.9	37.5	38.3	37.9	37.9	37.2
Iron	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	2.0	1.9	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Alkalinity	95	91	90	90	94	95	95	96	95	97	96	96	94.2

Year 1932

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	5.0	2.8	2.1	7.1	13.9	20.0	23.7	23.6	21.0	13.8	7.2	2.5	11.9
Temp.(Lorain)													
Total solids	163	167	170	170	172	176	174	172	176	179	172	168	171.6
Nitrate	1.19	1.21	1.24	1.24	1.25	1.28	1.27	1.25	1.28	1.31	1.25	1.23	1.25
Fluoride	.10	.10	.10	.10	.10	.11	.11	.10	.11	.11	.10	.10	.10
Chloride	17.8	18.2	18.6	18.6	18.8	19.2	19.0	18.8	19.2	19.6	18.8	18.4	18.8
Sulphate	24.7	25.3	25.9	25.9	26.1	26.7	26.4	26.1	26.7	27.2	26.1	25.6	26.1
Bicarbonate	112	114	117	117	118	120	119	118	120	123	118	115	118
Sodium plus potassium	9.4	9.6	9.8	9.8	9.9	10.1	10.0	9.9	10.1	10.3	9.9	9.7	9.9
Magnesium	8.4	8.6	8.7	8.7	8.8	9.0	8.9	8.8	9.0	9.2	8.8	8.6	8.8
Calcium	35.5	36.3	37.1	37.1	37.5	38.3	37.9	37.5	38.3	39.1	37.5	36.7	37.3
Iron	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	1.9	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.1	2.0	2.0	2.0
Alkalinity	90	92	94	94	95	97	96	95	97	99	95	93	94.8

Year 1933

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp. (Avon)	2.9	1.8	2.6	8.1	13.8	21.8	22.9	24.1	21.5	14.3	5.6	3.3	11.9
Temp. (Lorain)													
Total solids	163	172	168	165	167	181	177	177	179	176	176	161	172
Nitrate	1.19	1.25	1.23	1.20	1.21	1.32	1.29	1.29	1.31	1.28	1.28	1.17	1.25
Fluoride	.10	.10	.10	.10	.10	.11	.11	.11	.11	.11	.11	.10	.10
Chloride	17.8	18.8	18.4	18.0	18.2	19.8	19.4	19.4	19.6	19.2	19.2	17.6	18.8
Sulphate	24.7	26.1	25.6	25.0	25.3	27.5	26.9	26.9	27.2	26.7	26.7	24.5	26.1
Bicarbonate	112	118	115	113	114	124	122	122	123	120	120	110	118
Sodium plus potassium	9.4	9.9	9.7	9.5	9.6	10.4	10.2	10.2	10.3	10.1	10.1	9.3	9.9
Magnesium	8.4	8.8	8.6	8.5	8.6	9.3	9.1	9.1	9.2	9.0	9.0	8.3	8.8
Calcium	35.5	37.5	36.7	35.9	36.3	39.5	38.7	38.7	39.1	38.7	38.7	35.2	37.5
Iron	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	1.9	2.0	2.0	1.9	1.9	2.1	2.1	2.1	2.1	2.0	2.0	1.9	2.0
Alkalinity	90	95	93	91	92	100	98	98	99	97	97	89	94.9

Year 1934

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	1.8	1.6	1.9	6.4	14.2	21.1	24.9	24.1	20.8	14.8	8.1	2.7	11.9
Temp.(Lorain)													
Total solids	152	156	148	141	154	152	157	167	172	170	170	165	159
Nitrate	1.11	1.14	1.08	1.03	1.12	1.11	1.15	1.21	1.25	1.24	1.24	1.20	1.16
Fluoride	.09	.09	.09	.09	.09	.09	.10	.10	.10	.10	.10	.10	.10
Chloride	16.6	17.0	16.2	15.4	16.8	16.6	17.2	18.2	18.8	18.6	18.6	18.0	17.3
Sulphate	23.1	23.7	22.5	21.4	23.4	23.1	23.9	25.3	26.1	25.9	25.9	25.0	24.1
Bicarbonate	104	107	102	97	105	104	108	114	118	117	117	113	109
Sodium plus potassium	8.7	8.9	8.5	8.1	8.8	8.7	9.0	9.6	9.9	9.8	9.8	9.5	9.1
Magnesium	7.8	8.0	7.6	7.3	7.9	7.8	8.1	8.6	8.8	8.7	8.7	8.5	8.2
Calcium	33.2	34.0	32.4	30.8	33.6	33.2	34.4	36.3	37.5	37.1	37.1	35.9	34.6
Iron	.03	.03	.03	.03	.03	.03	.03	.04	.04	.04	.04	.04	.03
Silica	1.8	1.8	1.7	1.6	1.8	1.8	1.8	1.9	2.0	2.0	2.0	1.9	2.0
Alkalinity	84	86	82	78	85	84	87	92	95	94	94	91	87.7

Year 1935

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	1.9	1.6	4.9	8.2	13.0	18.8	24.8	25.2	20.4	13.7	9.3	2.6	12.0
Temp.(Lorain)													
Total solids	167	165	156	159	159	163	170	170	170	172	174	172	166
Nitrate	1.21	1.20	1.14	1.16	1.16	1.19	1.24	1.24	1.24	1.25	1.27	1.25	1.21
Fluoride	.10	.10	.09	.10	.10	.10	.10	.10	.10	.10	.11	.10	.10
Chloride	18.2	18.0	17.0	17.4	17.4	17.8	18.6	18.6	18.6	18.8	19.0	18.8	18.2
Sulphate	25.3	25.0	23.7	24.2	24.2	24.7	25.9	25.9	25.9	26.1	26.4	26.1	25.3
Bicarbonate	114	113	107	109	109	112	117	117	117	118	119	118	114
Sodium plus potassium	9.6	9.5	8.9	9.2	9.2	9.4	9.8	9.8	9.8	9.9	10.0	9.9	9.6
Magnesium	8.6	8.5	8.0	8.2	8.2	8.4	8.7	8.7	8.7	8.8	8.9	8.8	8.5
Calcium	36.3	35.9	34.0	34.8	34.8	35.5	37.1	37.1	37.1	37.5	37.9	37.5	36.3
Iron	.04	.04	.03	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	1.9	1.9	1.8	1.8	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	1.9
Alkalinity	92	91	86	88	88	90	94	94	94	95	96	95	91.9

Year 1936

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	1.7	1.3	3.3	6.4	14.8	20.1	23.9	24.3	21.9	14.9	6.6	2.6	11.8
Temp.(Lorain)	176	177	172	161	168	170	170	172	172	170	168	170	170
Nitrate	1.28	1.29	1.25	1.17	1.23	1.24	1.24	1.25	1.25	1.24	1.23	1.24	1.24
Fluoride	.11	.11	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10
Chloride	19.2	19.4	18.8	17.6	18.4	18.6	18.6	18.8	18.8	18.6	18.4	18.6	18.7
Sulphate	26.7	26.9	26.1	24.5	25.6	25.9	25.9	26.1	26.1	25.9	25.6	25.9	25.9
Bicarbonate	120	122	118	110	115	117	117	118	118	117	115	117	117
Sodium plus potassium	10.1	10.2	9.9	9.3	9.7	9.8	9.8	9.9	9.9	9.8	9.7	9.8	9.8
Magnesium	9.0	9.1	8.8	8.3	8.6	8.7	8.7	8.8	8.8	8.7	8.6	8.7	8.7
Calcium	38.3	38.7	37.5	35.2	36.7	37.1	37.1	37.5	37.5	37.1	36.7	37.1	37.2
Iron	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	2.0	2.1	2.0	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Alkalinity	97	98	95	89	93	94	94	95	95	94	93	94	94.3

Year 1937

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	2.9	1.8	1.7	7.2	13.6	20.2	23.8	23.9	20.3	12.9	6.2	1.8	11.4
Temp.(Lorain)													
Total solids	150	150	156	157	163	170	167	170	172	174	172	168	164
Nitrate	1.10	1.10	1.14	1.15	1.19	1.24	1.21	1.24	1.25	1.27	1.25	1.23	1.20
Fluoride	.09	.09	.09	.10	.10	.10	.10	.10	.10	.11	.10	.10	.10
Chloride	16.4	16.4	17.0	17.2	17.8	18.6	18.2	18.6	18.8	19.0	18.8	18.4	17.9
Sulphate	22.8	22.8	23.7	23.9	24.7	25.9	25.3	25.9	26.1	26.4	26.1	25.6	24.9
Bicarbonate	103	103	107	108	112	117	114	117	118	119	118	115	113
Sodium plus potassium	8.6	8.6	8.9	9.0	9.4	9.8	9.6	9.8	9.9	10.0	9.9	9.7	9.4
Magnesium	7.7	7.7	8.0	8.1	8.4	8.7	8.6	8.7	8.8	8.9	8.8	8.6	8.4
Calcium	32.8	32.8	34.0	34.4	35.5	37.1	36.3	37.1	37.5	37.9	37.5	36.7	35.8
Iron	.03	.03	.03	.03	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	1.7	1.7	1.8	1.8	1.9	2.0	1.9	2.0	2.0	2.0	2.0	2.0	1.9
Alkalinity	83	83	86	87	90	94	92	94	95	96	95	93	90.7

Year 1938

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	1.3	3.3	4.4	9.1	14.2	19.9	23.9	24.9	20.5	15.6	9.0	3.7	12.5
Temp.(Lorain)													
Total solids	174	163	159	161	168	170	167	165	167	168	167	167	166
Nitrate	1.27	1.19	1.16	1.17	1.23	1.24	1.21	1.20	1.21	1.23	1.21	1.21	1.21
Fluoride	.11	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10
Chloride	19.0	17.8	17.4	17.6	18.4	18.6	18.2	18.0	18.2	18.4	18.2	18.2	18.2
Sulphate	26.4	24.7	24.2	24.5	25.6	25.9	25.3	25.0	25.3	25.6	25.3	25.3	25.3
Bicarbonate	119	112	109	110	115	117	114	113	114	115	114	114	114
Sodium plus potassium	10.0	9.4	9.2	9.3	9.7	9.8	9.6	9.5	9.6	9.7	9.6	9.6	9.6
Magnesium	8.9	8.4	8.2	8.3	8.6	8.7	8.6	8.5	8.6	8.6	8.6	8.6	8.6
Calcium	37.9	35.5	34.8	35.2	36.7	37.1	36.3	35.9	36.3	36.7	36.3	36.3	36.3
Iron	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	2.0	1.9	1.8	1.9	2.0	2.0	1.9	1.9	1.9	2.0	1.9	1.9	1.9
Alkalinity	96	90	88	89	93	94	92	91	92	93	92	92	91.8

Year 1939

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	2.2	1.7	3.1	6.9	14.2	20.9	24.0	24.7	21.9	15.5	7.4	4.0	12.2
Temp.(Lorain)													
Total solids	167	159	154	156	159	159	161	165	165	165	163	159	161
Nitrate	1.21	1.16	1.12	1.14	1.16	1.16	1.17	1.20	1.20	1.20	1.19	1.16	1.17
Fluoride	.10	.10	.09	.09	.10	.10	.10	.10	.10	.10	.10	.10	.10
Chloride	18.2	17.4	16.8	17.0	17.4	17.4	17.6	18.0	18.0	18.0	17.8	17.4	17.6
Sulphate	25.3	24.2	23.4	23.7	24.2	24.2	24.5	25.0	25.0	25.0	24.7	24.2	24.5
Bicarbonate	114	109	105	107	109	109	110	113	113	113	112	109	110
Sodium plus potassium	9.6	9.2	8.8	8.9	9.2	9.2	9.3	9.5	9.5	9.5	9.4	9.2	9.3
Magnesium	8.6	8.2	7.9	8.0	8.2	8.2	8.3	8.5	8.5	8.5	8.4	8.2	8.3
Calcium	36.3	34.8	33.6	34.0	34.8	34.8	35.2	35.9	35.9	35.9	35.5	34.8	35.1
Iron	.04	.04	.03	.03	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	1.9	1.8	1.8	1.8	1.8	1.8	1.9	1.9	1.9	1.9	1.9	1.8	1.85
Alkalinity	92	88	85	86	88	88	89	91	91	91	90	88	88.9

Year 1940

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	1.8	1.5	1.6	4.4	12.2	19.8	22.8	23.1	20.4	15.4	7.9	3.6	11.2
Temp.(Lorain)													
Total solids	167	167	157	136	150	154	156	159	157	156	157	156	156
Nitrate	1.21	1.21	1.15	.99	1.10	1.12	1.14	1.16	1.15	1.14	1.15	1.14	1.14
Fluoride	.10	.10	.10	.08	.09	.09	.09	.10	.10	.09	.10	.09	.09
Chloride	18.2	18.2	17.2	14.8	16.4	16.8	17.0	17.4	17.2	17.0	17.2	17.0	17.0
Sulphate	25.3	25.3	23.9	20.6	22.8	23.4	23.7	24.2	23.9	23.7	23.9	23.7	23.7
Bicarbonate	114	114	108	93	103	105	107	109	108	107	108	107	107
Sodium plus potassium	9.6	9.6	9.0	7.8	8.6	8.8	8.9	9.2	9.0	8.9	9.0	8.9	8.9
Magnesium	8.6	8.6	8.1	7.0	7.7	7.9	8.0	8.2	8.1	8.0	8.1	8.0	8.0
Calcium	36.3	36.3	34.4	29.6	32.8	33.6	34.0	34.8	34.4	34.0	34.4	34.0	34.1
Iron	.04	.04	.03	.03	.03	.03	.03	.04	.03	.03	.03	.03	.03
Silica	1.9	1.9	1.8	1.6	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Alkalinity	92	92	87	75	83	85	86	88	87	86	87	86	86.2

Year 1941

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	1.7	1.8	2.1	7.7	16.2	20.4	24.5	24.5	21.6	16.1	8.0	4.8	12.5
Temp.(Lorain)													
Total solids	152	161	165	161	165	163	161	161	167	170	170	167	164
Nitrate	1.11	1.17	1.20	1.17	1.20	1.19	1.17	1.17	1.21	1.24	1.24	1.21	1.19
Fluoride	.09	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10
Chloride	16.6	17.6	18.0	17.6	18.0	17.8	17.6	17.6	18.2	18.6	18.6	18.2	17.9
Sulphate	23.1	24.5	25.0	24.5	25.0	24.7	24.5	24.5	25.3	25.9	25.9	25.3	24.8
Bicarbonate	104	110	113	110	113	112	110	110	114	117	117	114	112
Sodium plus potassium	8.7	9.3	9.5	9.3	9.5	9.4	9.3	9.3	9.6	9.8	9.8	9.6	9.4
Magnesium	7.8	8.3	8.5	8.3	8.5	8.4	8.3	8.3	8.6	8.7	8.7	8.6	8.4
Calcium	33.2	35.2	35.9	35.2	35.9	35.5	35.2	35.2	36.3	37.1	37.1	36.3	35.7
Iron	.03	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	1.7	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	2.0	2.0	1.9	1.9
Alkalinity	84	89	91	89	91	90	89	89	92	94	94	92	90.3

Year 1942

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp. (Avon)	2.2	1.7	3.9	9.2	14.1	19.7	23.8	24.1	20.8		8	1.8	11.1
Temp. (Lorain)													
Total solids	168	154	150	147	157	161	163	163	168	174	170	167	162
Nitrate	1.23	1.12	1.10	1.07	1.15	1.17	1.19	1.19	1.23	1.27	1.24	1.21	1.18
Fluoride	.10	.09	.09	.09	.10	.10	.10	.10	.10	.11	.10	.10	.10
Chloride	18.4	16.8	16.4	16.0	17.2	17.6	17.8	17.8	18.4	19.0	18.6	18.2	17.7
Sulphate	25.6	23.4	22.8	22.3	23.9	24.5	24.7	24.7	25.6	26.4	25.9	25.3	24.6
Bicarbonate	115	105	103	100	108	110	112	112	115	119	117	114	111
Sodium plus potassium	9.7	8.8	8.6	8.4	9.0	9.3	9.4	9.4	9.7	10.0	9.8	9.6	9.3
Magnesium	9.6	7.9	7.7	7.5	8.1	8.3	8.4	8.4	8.6	8.9	8.7	8.6	8.4
Calcium	36.7	33.6	32.8	32.0	34.4	35.2	35.5	35.5	36.7	37.9	37.1	36.3	35.3
Iron	.04	.03	.03	.03	.03	.04	.04	.04	.04	.04	.04	.04	.04
Silica	2.0	1.8	1.7	1.7	1.8	1.9	1.9	1.9	2.0	2.0	2.0	1.9	1.9
Alkalinity	93	85	83	81	87	89	90	90	93	96	94	92	89.4

Year 1943

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	2.0	1.6	3.4	7.2	12.6	20.8	24.5	24.6	19.7	14.1	6.8	2.6	11.7
Temp.(Lorain)													
Total solids		161	172	168	165	165	165	168	170	170	167	170	167
Nitrate		1.17	1.25	1.23	1.20	1.20	1.20	1.23	1.24	1.24	1.21	1.24	1.22
Fluoride		.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10
Chloride		17.6	18.8	18.4	18.0	18.0	18.0	18.4	18.6	18.6	18.2	18.6	18.3
Sulphate		24.5	26.1	25.6	25.0	25.0	25.0	25.6	25.9	25.9	25.3	25.9	25.5
Bicarbonate		110	118	115	113	113	113	115	117	117	114	117	115
Sodium plus potassium		9.3	9.9	9.7	9.5	9.5	9.5	9.7	9.8	9.8	9.6	9.8	9.6
Magnesium		8.3	8.8	8.6	8.5	8.5	8.5	8.6	8.7	8.7	8.6	8.7	8.6
Calcium		35.2	37.5	36.7	35.9	35.9	35.9	36.7	37.1	37.1	36.3	37.1	36.5
Iron		.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica		1.9	2.0	2.0	1.9	1.9	1.9	2.0	2.0	2.0	1.9	2.0	1.9
Alkalinity		89	95	93	91	91	91	93	94	94	92	94	92.5

Year 1944

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	1.9	2.4	2.6	6.4	14.1	21.3	23.9	23.6	20.2	15.3	8.8	2.1	11.9
Temp.(Lorain)													
Total solids	170	165	154	157	161	165	167	170	172	168	163	165	165
Nitrate	1.24	1.20	1.12	1.15	1.17	1.20	1.21	1.24	1.25	1.23	1.19	1.20	1.20
Fluoride	.10	.10	.09	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10
Chloride	18.6	18.0	16.8	17.2	17.6	18.0	18.2	18.6	18.8	18.4	17.8	18.0	18.0
Sulphate	25.9	25.0	23.4	23.9	24.5	25.0	25.3	25.9	26.1	25.6	24.7	25.0	25.0
Bicarbonate	117	113	105	108	110	113	114	117	118	115	112	113	113
Sodium plus potassium	9.8	9.5	8.8	9.0	9.3	9.5	9.6	9.8	9.9	9.7	9.4	9.5	9.5
Magnesium	8.7	8.5	7.9	8.1	8.3	8.5	8.6	8.7	8.8	8.6	8.4	8.5	8.5
Calcium	37.1	35.9	33.4	34.4	35.2	35.9	36.3	37.1	37.5	36.7	35.5	35.9	35.9
Iron	.04	.04	.03	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	2.0	1.9	1.8	1.8	1.9	1.9	1.9	2.0	2.0	2.0	1.9	1.9	1.9
Alkalinity	94	91	85	87	89	91	92	94	95	93	90	91	91

Year 1945

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	1.7	1.1	6.0	10.3	12.6	18.3	23.1	24.2	20.8	13.7	9.2	2.3	11.9
Temp.(Lorain)													
Total solids	168	167	152	152	157	167	165	165	168	165	163	163	163
Nitrate	1.23	1.21	1.11	1.11	1.15	1.21	1.20	1.20	1.23	1.20	1.19	1.19	1.19
Fluoride	.10	.10	.09	.09	.10	.10	.10	.10	.10	.10	.10	.10	.10
Chloride	18.4	18.2	16.6	16.6	17.2	18.2	18.0	18.0	18.4	18.0	17.8	17.8	17.8
Sulphate	25.6	25.3	23.1	23.1	23.9	25.3	25.0	25.0	25.6	25.0	24.7	24.7	24.7
Bicarbonate	115	114	104	104	108	114	113	113	115	113	112	112	111
Sodium plus potassium	9.7	9.6	8.7	8.7	9.0	9.6	9.5	9.5	9.7	9.5	9.4	9.4	9.4
Magnesium	8.6	8.6	7.8	7.8	8.1	8.6	8.5	8.5	8.6	8.5	8.4	8.4	8.4
Calcium	36.7	36.3	33.2	33.2	24.4	26.3	35.9	35.9	36.7	35.9	35.5	35.5	35.5
Iron	.04	.04	.03	.03	.03	.04	.04	.04	.04	.04	.04	.04	.04
Silica	2.0	1.9	1.8	1.8	1.8	1.9	1.9	1.9	2.0	1.9	1.9	1.9	1.9
Alkalinity	93	92	84	84	87	92	91	91	93	91	90	90	89.8

Year 1946

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	1.8	1.3	5.9	9.7	13.7	19.4	22.9	22.9	20.5	16.2	10.4	3.7	12.4
Temp.(Lorain)													
Total solids	152	159	165	165	168	157	161	163	167	165	163	161	162
Nitrate	1.11	1.16	1.20	1.20	1.23	1.15	1.17	1.19	1.21	1.20	1.19	1.17	1.18
Fluoride	.09	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10
Chloride	16.6	17.4	18.0	18.0	18.4	17.2	17.6	17.8	18.2	18.0	17.8	17.6	17.7
Sulphate	23.1	24.2	25.0	25.0	25.6	23.9	24.5	24.7	25.3	25.0	24.7	24.5	24.6
Bicarbonate	104	109	113	113	115	108	110	112	114	113	112	110	111
Sodium plus potassium	8.7	9.2	9.5	9.5	9.7	9.0	9.3	9.4	9.6	9.5	9.4	9.3	9.3
Magnesium	7.8	8.2	8.5	8.5	8.6	8.1	8.3	8.4	8.6	8.5	8.4	8.3	8.3
Calcium	33.2	34.8	35.9	35.9	36.7	34.4	35.2	35.5	36.3	35.9	35.5	35.2	35.4
Iron	.03	.04	.04	.04	.04	.03	.04	.04	.04	.04	.04	.04	.04
Silica	1.8	1.8	1.9	1.9	2.0	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Alkalinity	84	88	91	91	93	87	89	90	92	91	90	89	89.6

Year 1947

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	1.9	1.4	1.6	7.3	11.7	17.5	22.6	25.2	22.6	17.3	9.0	2.7	11.7
Temp.(Lorain)													
Total solids	156	156	159	143	141	154	163	167	167	167	165	163	158
Nitrate	1.14	1.14	1.16	1.04	1.03	1.12	1.19	1.21	1.21	1.21	1.20	1.90	1.15
Fluoride	.09	.09	.10	.09	.09	.09	.10	.10	.10	.10	.10	.10	.10
Chloride	17.0	17.0	17.4	15.6	15.4	16.8	17.8	18.2	18.2	18.2	18.0	17.8	17.3
Sulphate	23.7	23.7	24.2	21.7	21.4	23.4	24.7	25.3	25.3	25.3	25.0	24.7	24.0
Bicarbonate	107	107	109	98	97	105	112	114	114	114	113	112	108
Sodium plus potassium	8.9	8.9	9.2	8.2	8.1	8.8	9.4	9.6	9.6	9.6	9.5	9.4	9.1
Magnesium	8.0	8.0	8.2	7.3	7.3	7.9	8.4	8.6	8.6	8.6	8.5	8.4	8.1
Calcium	34.0	34.0	34.8	31.2	30.8	33.6	35.5	36.3	36.3	36.3	35.9	35.5	34.5
Iron	.03	.03	.04	.03	.03	.03	.04	.04	.04	.04	.04	.04	.03
Silica	1.8	1.8	1.8	1.7	1.6	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.8
Alkalinity	86	86	88	79	78	85	90	92	92	92	91	90	87.4

Year 1948

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp. (Avon)	1.7	1.4	4.4	9.9	14.8	19.9	23.7	23.8	21.9	13.8	9.7	5.8	12.6
Temp. (Lorain)													
Total solids	163	161	157	154	156	163	163	161	159	159	165	161	160
Nitrate	1.19	1.17	1.15	1.12	1.14	1.19	1.19	1.17	1.16	1.16	1.20	1.17	1.17
Fluoride	.10	.10	.10	.09	.09	.10	.10	.10	.10	.10	.10	.10	.10
Chloride	17.8	17.6	17.2	16.8	17.0	17.8	17.8	17.6	17.4	17.4	18.0	17.6	17.5
Sulphate	24.7	24.5	23.9	23.4	23.7	24.7	24.7	24.5	24.2	24.2	25.0	24.5	24.3
Bicarbonate	112	110	108	105	107	112	112	110	109	109	113	110	110
Sodium plus potassium	9.4	9.3	9.0	8.8	8.9	9.4	9.4	9.3	9.2	9.2	9.5	9.3	9.2
Magnesium	8.4 10*	8.3 6.4*	8.1 5.9*	7.9 5.5*	8.0 6.2*	8.4 6.6*	8.4 6.2*	8.3 6.7*	8.2 6.4*	8.2 6.4*	8.5 6.5*	8.3 6.3*	8.2
Calcium	35.5	35.2	34.4	33.6	34.0	35.5	35.5	35.2	34.8	34.8	35.9	35.2	35.0
Iron	.04	.04	.03	.03	.03	.04	.04	.04	.04	.04	.04	.04	.04
Silica	1.9	1.9	1.8	1.8	1.8	1.9	1.9	1.9	1.8	1.8	1.9	1.9	1.9
Alkalinity	90	89	87	85	86	90	90	89	88	88	91	89	88.5

*Observed magnesium

Year 1949

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	4.1	3.9	5.2	9.5	15.6	21.4	25.2	25.4	19.7	16.6	8.7	4.3	13.3
Temp.(Lorain)													
Total solids	159	159	159	154	156	156	159	163	161	163	165	157	159
Nitrate	1.16	1.16	1.16	1.12	1.14	1.14	1.16	1.19	1.17	1.19	1.20	1.15	1.16
Fluoride	.10	.10	.10	.09	.09	.09	.10	.10	.10	.10	.10	.10	.10
Chloride	17.4	17.4	17.4	16.8	17.0	17.0	17.4	17.8	17.6	17.8	18.0	17.2	17.4
Sulphate	24.2	24.2	24.2	23.4	23.7	23.7	24.2	24.7	24.5	24.7	25.0	23.9	24.2
Bicarbonate	109	109	109	105	107	107	109	112	110	112	113	108	109
Sodium plus potassium	9.2	9.2	9.2	8.8	8.9	8.9	9.2	9.4	9.3	9.4	9.5	9.0	9.2
Magnesium	8.2	8.2	8.2	7.9	8.0	8.0	8.2	8.4	8.3	8.4	8.5	8.1	8.2
	6.5*	6.4*	7.4*	6.7*	5.9*	5.7*	5.7*	5.5*	5.4*	5.5*	5.2*	5.1*	
Calcium	34.8	34.8	34.8	33.6	34.0	34.0	34.8	35.5	35.2	35.5	35.9	34.4	34.8
Iron	.04	.04	.04	.03	.03	.03	.04	.04	.04	.04	.04	.03	.04
Silica	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.9	1.9	1.9	1.9	1.8	1.8
Alkalinity	88	88	88	85	86	86	88	90	89	90	91	87	88

*Observed magnesium

Year 1950

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	4.8	3.2	2.2	6.8	11.9	19.4	21.9	23.4	20.3	16.0	9.2	2.7	11.8
Temp.(Lorain)													
Total solids	145	147	148	154	154	163	165	165	167	165	163	154	157
Nitrate	1.06	1.07	1.08	1.12	1.12	1.19	1.20	1.20	1.21	1.20	1.19	1.12	1.15
Fluoride	.09	.09	.09	.09	.09	.10	.10	.10	.10	.10	.10	.09	.10
Chloride	15.8	16.0	16.2	16.8	16.5	17.8	18.0	18.0	18.2	18.0	17.8	16.8	17.2
Sulphate	22.0	22.3	22.5	23.4	23.4	24.7	25.0	25.0	25.3	25.0	24.7	23.4	23.9
Bicarbonate	99	100	102	105	105	112	113	113	114	113	112	105	108
Sodium plus potassium	8.3	8.4	8.5	8.8	8.8	9.4	9.5	9.5	9.6	9.5	9.4	8.8	9.0
Magnesium	7.4 6.2*	7.5 5.7*	7.6 6.3*	7.9 7.6*	7.9 8.3*	8.4 9.2*	8.5 9.1*	8.5 8.9*	8.6 8.5*	8.5 8.5*	8.4 8.5*	7.9 8.8*	8.1
Calcium	31.6	32.0	32.4	33.6	33.6	35.5	35.9	35.9	36.3	35.9	35.5	33.6	34.3
Iron	.03	.03	.03	.03	.03	.04	.04	.04	.04	.04	.04	.03	.03
Silica	1.7	1.7	1.7	1.8	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.8	1.8
Alkalinity	80	81	82	85	85	90	91	91	92	91	90	85	86.9

*Observed magnesium

Year 1951

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp. (Avon)	2.2	2.0	5.4	8.0	13.8	20.5	23.3	23.9	20.7	16.0	7.4	3.6	12.2
Temp. (Lorain)													
Total solids	157	157	163	161	167	176	176	181	181	181	172	165	170
Nitrate	1.15	1.15	1.19	1.17	1.21	1.28	1.28	1.32	1.32	1.32	1.25	1.20	1.24
Fluoride	.10	.10	.10	.10	.10	.11	.11	.11	.11	.11	.10	.10	.10
Chloride	17.2	17.2	17.8	17.6	18.2	19.2	19.2	19.8	19.8	19.8	18.8	18.0	18.6
Sulphate	23.9	23.9	24.7	24.5	25.3	26.7	26.7	27.5	27.5	27.5	26.1	25.0	25.8
Bicarbonate	108	108	112	110	114	120	120	124	124	124	118	113	116
Sodium plus potassium	9.0	9.0	9.4	9.3	9.6	10.1	10.1	10.4	10.4	10.4	9.9	9.5	9.7
Magnesium	8.1	8.1	8.4	8.3	8.6	9.0	9.0	9.3	9.3	9.3	8.8	8.5	8.7
	8.6*	8.6*	9.1*	9.0*	9.3*	9.3*	8.8*	8.7*	8.8*	8.7*	8.6*	8.3*	
Calcium	34.4	34.4	35.5	35.2	36.3	38.3	38.3	39.5	39.5	39.5	37.5	35.9	37.0
Iron	.03	.03	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	1.8	1.8	1.9	1.9	1.9	2.0	2.0	2.1	2.1	2.1	2.0	1.9	2.0
Alkalinity	87	87	90	89	92	97	97	100	100	100	95	91	93.7

*Observed magnesium

Year 1952

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	3.2	2.4	2.8	8.0	13.1	20.8	24.5	24.1	21.7	14.8	8.7	5.1	12.4
Temp.(Lorain)													
Total solids	161	157	150	154	161	168	167	172	172	174	176	168	165
Nitrate	1.17	1.15	1.10	1.12	1.17	1.23	1.21	1.25	1.25	1.27	1.28	1.23	1.20
Fluoride	.10	.10	.09	.10	.10	.10	.10	.10	.10	.11	.11	.10	.10
Chloride	17.6	17.2	16.4	16.8	17.6	18.4	18.2	18.8	18.8	19.0	19.2	18.4	18.1
Sulphate	24.5	23.9	22.8	23.4	24.5	25.6	25.3	26.1	26.1	26.4	26.7	25.6	25.1
Bicarbonate	110	108	103	105	110	115	114	118	118	119	120	115	113
Sodium plus potassium	9.3	9.0	8.6	8.8	9.3	9.7	9.6	9.9	9.9	10.0	10.1	9.7	9.5
Magnesium	8.3	8.1	7.7	7.9	8.3	8.6	8.6	8.8	8.8	8.9	9.0	8.6	8.5
	8.3*	8.5*	8.2*	8.3*	9.9*	8.1*	8.2*	8.3*	8.4*	8.1*	8.5*	8.3*	[illegible]
Calcium	35.2	34.4	32.8	33.6	35.2	36.7	36.3	37.5	37.5	37.9	38.3	36.7	36.0
Iron	.04	.03	.03	.03	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	1.9	1.8	1.7	1.8	1.9	2.0	1.9	2.0	2.0	2.0	2.0	2.0	1.9
Alkalinity	89	87	83	85	89	93	92	95	95	96	97	93	91.2

*Observed magnesium

Year 1953

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	3.6	3.6	4.6	8.2	12.6	19.1	23.5	24.5	21.8	16.7	10.4	4.6	12.8
Temp.(Lorain)													
Total solids	163	157	157	159	157	161	163	165	167	167	161	165	162
Nitrate	1.19	1.15	1.15	1.16	1.15	1.17	1.19	1.20	1.21	1.21	1.17	1.20	1.18
Fluoride	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10
Chloride	17.8	17.2	17.2	17.4	17.2	17.6	17.8	18.0	18.2	18.2	17.6	18.0	17.7
Sulphate	24.7	23.9	23.9	24.2	23.9	24.5	24.7	25.0	25.3	25.3	24.5	25.0	24.6
Bicarbonate	112	108	108	109	108	110	112	113	114	114	110	113	111
Sodium plus potassium	9.4	9.0	9.0	9.2	9.0	9.3	9.4	9.5	9.6	9.6	9.3	9.5	9.3
Magnesium	8.4	8.1	8.1	8.2	8.1	8.3	8.4	8.5	8.6	8.6	8.3	8.5	8.3
	8.8*	9.1*	8.8*	9.8*	9.1*	8.8*	8.8*	9.5*	8.5*	8.5*	8.4*	8.5*	
Calcium	35.5	34.4	34.4	34.8	34.4	35.2	35.5	35.9	36.3	36.3	35.2	35.9	35.3
Iron	.04	.03	.03	.04	.03	.04	.04	.04	.04	.04	.04	.04	.04
Silica	1.9	1.8	1.8	1.8	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Alkalinity	90	87	87	88	87	89	90	91	92	92	89	91	89.4

*Observed magnesium

Year 1954

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp. (Avon)	1.6	2.8	3.5	9.0	13.2	19.7	23.7	23.6	21.3	16.6	9.1	3.8	12.3
Temp. (Lorain)													
Total solids	165	159	154	148	161	161	157	165	167	165	163	161	161
Nitrate	1.20	1.16	1.12	1.08	1.17	1.17	1.15	1.20	1.21	1.20	1.19	1.17	1.17
Fluoride	.10	.10	.09	.09	.10	.10	.10	.10	.10	.10	.10	.10	.10
Chloride	18.0	17.4	16.8	16.2	17.6	17.6	17.2	18.0	18.2	18.0	17.8	17.6	17.6
Sulphate	25.0	24.2	23.4	22.5	24.5	24.5	23.9	25.0	25.3	25.0	24.7	24.5	24.4
Bicarbonate	113	109	105	102	110	110	108	113	114	113	112	110	110
Sodium plus potassium	9.5	9.2	8.8	8.5	9.3	9.3	9.0	9.5	9.6	9.5	9.4	9.3	9.2
Magnesium	8.5	8.2	7.9	7.6	8.3	8.3	8.1	8.5	8.6	8.5	8.4	8.3	8.2
	8.1*	7.6*	7.7*	8.8*	8.9*	8.1*	8.3*	8.4*	8.6*	7.5*	8.2*	8.0*	
Calcium	35.9	34.8	33.6	32.4	35.2	35.2	34.4	35.9	36.3	35.9	35.5	35.2	35.0
Iron	.04	.04	.03	.03	.04	.04	.03	.04	.04	.04	.04	.04	.04
Silica	1.9	1.8	1.8	1.7	1.9	1.9	1.8	1.9	1.9	1.9	1.9	1.9	1.9
Alkalinity	91	88	85	82	89	89	87	91	92	91	90	89	88.7

*Observed magnesium

Year 1955

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.(Avon)	1.7	.9	3.8	8.9	15.7	19.4	24.9	25.7	21.7	16.2	8.1	1.9	12.4
Temp.(Lorain)													
Total solids	163	159	157	157	161	163	163	163	165	163			161
Nitrate	1.19	1.16	1.15	1.15	1.17	1.19	1.19	1.19	1.20	1.19			1.18
Fluoride	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10			.10
Chloride	17.8	17.4	17.2	17.2	17.6	17.8	17.8	17.8	18.0	17.8			17.7
Sulphate	24.7	24.2	23.9	23.9	24.5	24.7	24.7	24.7	25.0	24.7			24.5
Bicarbonate	112	109	109	109	110	112	112	112	113	112			111
Sodium plus potassium	9.4	9.2	9.0	9.0	9.3	9.4	9.4	9.4	9.5	9.4			9.3
Magnesium	8.4	8.2	8.1	8.1	8.3	8.4	8.4	8.4	8.5	8.4			8.3
			9.7*	7.2*	7.5*	8.0*	8.3*	8.7*	9.3*				
Calcium	35.5	34.8	34.4	34.4	35.2	35.5	35.5	35.5	35.9	35.5			35.2
Iron	.04	.04	.03	.03	.04	.04	.04	.04	.04	.04			.04
Silica	1.9	1.8	1.8	1.8	1.9	1.9	1.9	1.9	1.9	1.9			1.9
Alkalinity	90	88	87	87	89	90	90	90	91	90			89.2

*Observed magnesium

Year 1956

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp. (Avon)	.8	.4	3.2	7.9	12.4	18.9	22.7	23.6		15.7	9.9	4.5	10.0
Temp. (Lorain)													
Total solids	163	154	157	163	161	161	161	165	168	170	167	168	163
Nitrate	1.19	1.12	1.15	1.19	1.17	1.17	1.17	1.20	1.23	1.24	1.21	1.23	1.19
Fluoride	.10	.09	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10	.10
Chloride	17.8	16.8	17.2	17.8	17.6	17.6	17.6	18.0	18.4	18.6	18.2	18.4	17.9
Sulphate	24.7	23.4	23.9	24.7	24.5	24.5	24.5	25.0	25.6	25.9	25.3	25.6	24.8
Bicarbonate	112	105	108	112	110	110	110	113	115	117	114	115	112
Sodium plus potassium	9.4	8.8	9.0	9.4	9.3	9.3	9.3	9.5	9.8	9.8	9.6	9.7	9.4
Magnesium	8.4	7.9	8.1	8.4	8.3	8.3	8.3	8.5	8.6	8.7	8.6	8.6	8.4
		7.6*	9.2*	8.3*	7.7*	7.1*	8.4*	8.3*		9.2*			
Calcium	35.5	33.6	34.4	35.5	35.2	35.2	35.2	35.9	36.7	37.1	36.3	36.7	35.6
Iron	.04	.03	.03	.04	.04	.04	.04	.04	.04	.04	.04	.04	.04
Silica	1.9	1.8	1.8	1.9	1.9	1.9	1.9	1.9	2.0	2.0	1.9	2.0	1.9
Alkalinity	90	85	87	90	89	89	89	91	93	94	92	93	90.2

*Observed magnesium

Year 1957

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp. (Avon)	.6	.8	3.3	6.8	14.3	18.9	23.3	24.1	21.3	14.7	8.7	3.9	11.7
Temp. (Lorain)													
Total solids	168	165	163	156	165	148	170	165	168	168	167	167	164
Nitrate	1.23	1.20	1.19	1.14	1.20	1.08	1.24	1.20	1.23	1.23	1.21	1.21	1.20
Fluoride	.10	.10	.10	.09	.10	.09	.10	.10	.10	.10	.10	.10	.10
Chloride	18.4	18.0	17.8	17.0	18.0	16.2	18.6	18.0	18.4	18.4	18.2	18.2	18.0
Sulphate	25.6	25.0	24.7	23.7	25.0	22.5	25.9	25.0	25.6	25.6	25.3	25.3	24.9
Bicarbonate	115	113	112	107	113	102	117	113	115	115	114	114	112
Sodium plus potassium	9.7	9.5	9.4	8.9	9.5	8.5	9.8	9.5	9.7	9.7	9.6	9.6	9.4
Magnesium	8.6	8.5	8.4	8.0	8.5	7.6	8.7	8.5	8.6	8.6	8.6	8.6	8.4
Calcium	36.7	35.9	35.5	34.0	35.9	32.4	37.1	35.9	36.7	36.7	36.3	36.3	35.8
Iron	.04	.04	.04	.03	.04	.03	.04	.04	.04	.04	.04	.04	.04
Silica	2.0	1.9	1.9	1.8	1.9	1.7	2.0	1.9	2.0	2.0	1.9	1.9	1.9
Alkalinity	93	91	90	86	91	82	94	91	93	93	92	92	90.7

Part 2. Station at Erie, Pennsylvania

Year 1918

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	1.1	1.4	1.7	3.2	10.6	16.4	20.9	22.9	18.7	14.3	10.2	5.2	10.6

Year 1919

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	1.4	1.0	2.6	5.7	9.7	13.6	17.2	21.9	20.8	16.6	9.8	2.8	10.3

Year 1920

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.	Ratio*
Temp.	1.0	1.0	1.3	4.2	9.7	13.8	20.7	21.6	19.9	16.9	9.0	4.7	10.3	
Total solids	175	177	173	165	173	177	173	171	173	173	175	173	173	1.9
Nitrate	.41	.42	.41	.39	.41	.42	.41	.40	.41	.41	.41	.41	.41	.0045
Chloride	20.4	20.6	20.2	19.3	20.2	20.6	20.2	20.0	20.2	20.2	20.4	20.2	20.2	.222
Sulphate	23.6	23.8	23.3	22.3	23.3	23.8	23.3	23.0	23.3	23.3	23.6	23.3	23.3	.256
Bicarbonate	155	157	154	147	154	157	154	152	154	154	155	154	154	1.689
Sodium plus potassium	8.9	9.0	8.8	8.4	8.8	9.0	8.8	8.7	8.8	8.8	8.9	8.8	8.8	.097
Magnesium	9.1	9.2	9.0	8.6	9.0	9.2	9.0	8.9	9.0	9.0	9.1	9.0	9.0	.099
Calcium	36.8	37.2	36.4	34.8	36.4	37.2	36.4	36.0	36.4	36.4	36.8	36.4	36.4	.400
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.0001
Silica	1.6	1.6	1.5	1.5	1.5	1.6	1.5	1.5	1.5	1.5	1.6	1.5	1.5	.017
Alkalinity	92	93	91	87	91	93	91	90	91	91	92	91	91.1	

*The "ratio" values indicated are the ratio of the parameter in question to alkalinity, i.e., "ratio" = parameter/alkalinity. These values apply to years 1920-1956, pages 113-148.

Year 1921

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	1.8	1.0	3.3	8.4	12.3	16.8	23.9	22.8	22.1	14.9	9.3	4.3	11.7
Total solids	175	177	171	163	169	173	177	175	179	177	177	177	174
Nitrate	.41	.42	.40	.39	.40	.41	.42	.41	.42	.42	.42	.42	.41
Chloride	20.4	20.6	20.0	19.1	19.8	20.2	20.6	20.4	20.9	20.6	20.6	20.6	20.3
Sulphate	23.6	23.8	23.0	22.0	22.8	23.3	23.8	23.6	24.1	23.8	23.8	23.8	23.4
Bicarbonate	155	157	152	145	150	154	157	155	159	157	157	157	155
Sodium plus potassium	8.9	9.0	8.7	8.3	8.6	8.8	9.0	8.9	9.1	9.0	9.0	9.0	8.9
Magnesium	9.1	9.2	8.9	8.5	8.8	9.0	9.2	9.1	9.3	9.2	9.2	9.2	9.1
Calcium	36.8	37.2	36.0	34.4	35.6	36.4	37.2	36.8	37.6	37.2	37.2	37.2	36.6
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.6	1.6	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Alkalinity	92	93	90	86	89	91	93	92	94	93	93	93	91.6

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Year 1922													
Temp.	0.9	0.6	1.2	6.4	10.2	16.6	21.7	22.1	21.1	16.0	9.6	2.8	10.8
Year 1923													
Temp.	0.9	0.4	0.7	2.9	7.6	16.8	19.4	19.7	18.9	15.1	8.3	5.6	9.7
Total solids	181	179	179	181	179	177	177	177	179	175	173	175	177
Nitrate	.43	.42	.42	.43	.42	.42	.42	.42	.42	.41	.41	.41	.42
Chloride	21.1	20.9	20.9	21.1	20.9	20.6	20.6	20.6	20.9	20.4	20.2	20.4	20.7
Sulphate	24.3	24.1	24.1	24.3	24.1	23.8	23.8	23.8	24.1	23.6	23.3	23.6	23.9
Bicarbonate	160	159	159	160	159	157	157	157	159	155	154	155	158
Sodium plus potassium	9.2	9.1	9.1	9.2	9.1	9.0	9.0	9.0	9.1	8.9	8.8	8.9	9.1
Magnesium	9.4	9.3	9.3	9.4	9.4	9.2	9.2	9.2	9.3	9.1	9.0	9.1	9.2
Calcium	38.0	37.6	37.6	38.0	37.6	37.2	37.2	37.2	37.6	36.8	36.4	36.8	37.3
Iron	.010	.009	.009	.010	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.6	1.6
Alkalinity	95	94	94	95	94	93	93	93	94	92	91	92	93.3

Year 1924

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	0.2	0.3	0.4	2.1	7.1	13.4	21.3	22.2	18.4	14.9	9.6	3.4	9.4
Total solids	175	175	175	177	179	177	173	177	179	179	177	173	176
Nitrate	.41	.41	.41	.42	.42	.42	.41	.42	.42	.42	.42	.41	.42
Chloride	20.4	20.4	20.4	20.6	20.9	20.6	20.2	20.6	20.9	20.9	20.6	20.2	20.6
Sulphate	23.6	23.6	23.6	23.8	24.1	23.8	23.3	23.8	24.1	24.1	23.8	23.3	23.7
Bicarbonate	155	155	155	157	159	157	154	157	159	159	157	154	157
Sodium plus potassium	8.9	8.9	8.9	9.0	9.1	9.0	8.9	9.0	9.1	9.1	9.0	8.8	9.0
Magnesium	9.1	9.1	9.1	9.2	9.3	9.2	9.0	9.2	9.3	9.3	9.2	9.0	9.2
Calcium	36.8	36.8	36.8	37.2	37.6	37.2	36.4	37.2	37.6	37.6	37.2	36.4	37.1
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.6	1.6	1.6	1.6	1.5	1.6
Alkalinity	92	92	92	93	94	93	91	93	94	94	93	91	92.7

Year 1925

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	0.3	0.4	0.9	4.2	10.0	17.9	20.9	22.2	21.1	13.8	6.4	2.4	10.0
Total solids	173	175	173	173	175	173	171	171	171	173	171	171	173
Nitrate	.41	.41	.41	.41	.41	.41	.40	.40	.40	.41	.40	.40	.41
Chloride	20.2	20.4	20.2	20.2	20.4	20.2	20.0	20.0	20.0	20.2	20.0	20.0	20.2
Sulphate	23.3	23.6	23.3	23.3	23.6	23.3	23.0	23.0	23.0	23.3	23.0	23.0	23.2
Bicarbonate	154	155	154	154	155	154	152	152	152	154	152	152	153
Sodium plus potassium	8.8	8.9	8.8	8.8	8.9	8.8	8.7	8.7	8.7	8.8	8.7	8.7	8.8
Magnesium	9.0	9.1	9.0	9.0	9.1	9.0	8.9	8.9	8.9	9.0	8.9	8.9	9.0
Calcium	36.4	36.8	36.4	36.4	36.8	36.4	36.0	36.0	36.0	36.4	36.0	36.0	36.3
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.5	1.6	1.5	1.5	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Alkalinity	91	92	91	91	92	91	90	90	90	91	90	90	90.8

Year 1926

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	0.3	0.3	0.3	1.7	8.7	15.8	19.1	22.8	21.1	16.9	10.3	4.1	10.1
Total solids	171	171	175	177	175	177	177	177	179	175	175	177	175
Nitrate	.40	.40	.41	.42	.41	.42	.42	.42	.42	.41	.41	.42	.42
Chloride	20.0	20.0	20.4	20.6	20.4	20.6	20.6	20.6	20.9	20.4	20.4	20.6	20.5
Sulphate	23.0	23.0	23.6	23.8	23.6	23.8	23.8	23.8	24.1	23.6	23.6	23.8	23.6
Bicarbonate	152	152	155	157	155	157	157	157	159	155	155	157	156
Sodium plus potassium	8.7	8.7	8.9	9.0	8.9	9.0	9.0	9.0	9.1	8.9	8.9	9.0	9.0
Magnesium	8.9	8.9	9.1	9.2	9.1	9.2	9.2	9.2	9.3	9.1	9.1	9.2	9.1
Calcium	36.0	36.0	36.8	37.2	36.8	37.2	37.2	37.2	37.6	36.8	36.8	37.2	36.9
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Alkalinity	90	90	92	93	92	93	93	93	94	92	92	93	92.3

Year 1927

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.1	2.0	2.6	5.4	11.4	16.7	21.8	22.4	21.2	16.7	11.4	5.8	11.6
Total solids	177	177	179	179	179	181	179	181	182	184	184	184	181
Nitrate	.42	.42	.42	.42	.42	.43	.42	.43	.43	.44	.44	.44	.43
Chloride	20.6	20.6	20.9	20.9	20.9	21.1	20.9	21.1	21.3	21.5	21.5	21.5	21.1
Sulphate	23.8	23.8	24.1	24.1	24.1	24.3	24.1	24.3	24.6	24.8	24.8	24.8	24.3
Bicarbonate	157	157	179	179	179	160	159	160	162	164	164	164	160
Sodium plus potassium	9.0	9.0	9.1	9.1	9.1	9.2	9.1	9.2	9.3	9.4	9.4	9.4	9.2
Magnesium	9.2	9.2	9.3	9.3	9.3	9.4	9.4	9.5	9.5	9.6	9.6	9.6	9.5
Calcium	37.2	37.2	37.6	37.6	37.6	38.0	37.6	38.0	38.4	38.8	38.8	38.8	38.0
Iron	.009	.009	.009	.009	.009	.010	.009	.010	.010	.010	.010	.010	.009
Silica	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Alkalinity	93	93	94	94	94	95	94	95	96	97	97	97	94.9

Year 1928

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.4	1.4	2.0	4.7	10.2	15.3	21.8	22.3	20.2	15.7	10.5	6.0	11.0
Total solids	184	184	184	184	184	184	182	182	184	186	184	184	184
Nitrate	.44	.44	.44	.44	.44	.44	.43	.43	.44	.44	.44	.44	.44
Chloride	21.5	21.5	21.5	21.5	21.5	21.5	21.3	21.3	21.5	21.8	21.5	21.5	21.5
Sulphate	24.8	24.8	24.8	24.8	24.8	24.8	24.6	24.6	24.8	25.1	24.8	24.8	24.8
Bicarbonate	164	164	164	164	164	164	162	162	164	166	164	164	164
Sodium plus potassium	9.4	9.4	9.4	9.4	9.4	9.4	9.3	9.3	9.4	9.5	9.4	9.4	9.4
Magnesium	9.6	9.6	9.6	9.6	9.6	9.6	9.5	9.5	9.6	9.7	9.6	9.6	9.6
Calcium	38.8	38.8	38.8	38.8	38.8	38.8	38.4	38.4	38.8	39.2	38.8	38.8	38.8
Iron	.010	.010	.010	.010	.010	.010	.010	.010	.010	.010	.010	.010	.010
Silica	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.7	1.6	1.6	1.6
Alkalinity	97	97	97	97	97	97	96	96	97	98	97	97	96.9

Year 1929

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.1	2.6	2.8	7.8	11.7	17.4	21.6	21.8	20.3	14.4	9.2	3.8	11.3
Total solids	184	184	182	182	179	175	175	177	177	181	181	181	180
Nitrate	.44	.44	.43	.43	.42	.41	.41	.42	.42	.43	.43	.43	.43
Chloride	21.5	21.5	21.3	21.3	20.9	20.4	20.4	20.6	20.6	21.1	21.1	21.1	21.0
Sulphate	24.8	24.8	24.6	24.6	24.1	23.6	23.6	23.8	23.8	24.3	24.3	24.3	24.2
Bicarbonate	164	164	162	162	159	155	155	157	157	160	160	160	160
Sodium plus potassium	9.4	9.4	9.3	9.3	9.1	8.9	8.9	9.0	9.0	9.2	9.2	9.2	9.2
Magnesium	9.6	9.6	9.5	9.5	9.3	9.1	9.1	9.2	9.2	9.4	9.4	9.4	9.4
Calcium	38.8	38.8	38.4	38.4	37.6	36.8	36.8	37.2	37.2	38.0	38.0	38.0	37.8
Iron	.010	.010	.010	.010	.009	.009	.009	.009	.009	.010	.010	.010	.009
Silica	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Alkalinity	97	97	96	96	94	92	92	93	93	95	95	95	94.6

Year 1930

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.7	2.1	3.1	5.6	12.1	17.5	22.9	22.9	20.9	15.7	9.8	4.9	11.7
Total solids	179	179	175	173	175	175	175	173	173	173	173	175	175
Nitrate	.42	.42	.41	.41	.41	.41	.41	.41	.41	.41	.41	.41	.41
Chloride	20.9	20.9	20.4	20.2	20.4	20.4	20.4	20.2	20.2	20.2	20.2	20.4	20.4
Sulphate	24.1	24.1	23.6	23.3	23.6	23.6	23.6	23.3	23.3	23.3	23.3	23.6	23.6
Bicarbonate	159	159	155	154	155	155	155	154	154	154	154	155	155
Sodium plus potassium	9.1	9.1	8.9	8.8	8.9	8.9	8.9	8.8	8.8	8.8	8.8	8.9	8.9
Magnesium	9.3	9.3	9.1	9.0	9.1	9.1	9.1	9.0	9.0	9.0	9.0	9.1	9.1
Calcium	37.6	37.6	36.8	36.4	36.8	36.8	36.8	36.4	36.4	36.4	36.4	36.4	36.4
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.6	1.6	1.6	1.5	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.6	1.6
Alkalinity	94	94	92	91	92	92	92	91	91	91	91	92	91.9

Year 1931

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	1.7	1.7	2.1	5.6	10.9	17.2	22.3	23.3	21.9	17.4	12.2	7.3	12.0
Total solids	175	175	173	175	175	173	173	173	173	175	175	175	174
Nitrate	.41	.41	.41	.41	.41	.41	.41	.41	.41	.41	.41	.41	.41
Chloride	20.4	20.4	20.2	20.4	20.4	20.2	20.2	20.2	20.2	20.4	20.4	20.4	20.3
Sulphate	23.6	23.6	23.3	23.6	23.6	23.3	23.3	23.3	23.3	23.6	23.6	23.6	23.4
Bicarbonate	155	155	154	155	155	154	154	154	154	155	155	155	155
Sodium plus potassium	8.9	8.9	8.8	8.9	8.9	8.8	8.8	8.8	8.8	8.9	8.9	8.9	8.9
Magnesium	9.1	9.1	9.0	9.1	9.1	9.0	9.0	9.0	9.0	9.1	9.1	9.1	9.1
Calcium	36.8	36.8	36.4	36.8	36.8	36.4	36.4	36.4	36.4	36.8	36.8	36.8	36.6
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.6	1.6	1.5	1.6	1.6	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6
Alkalinity	92	92	91	92	92	91	91	91	91	92	92	92	91.6

Year 1932

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	5.7	3.7	3.1	4.6	10.2	16.6	22.1	22.8	21.2	15.6	10.0	5.2	11.7
Total solids	175	173	175	175	173	173	177	179	184	184	182	181	177
Nitrate	.41	.41	.41	.41	.41	.41	.42	.42	.44	.44	.43	.43	.42
Chloride	20.4	20.2	20.4	20.4	20.2	20.2	20.6	20.9	21.5	21.5	21.3	21.1	20.7
Sulphate	23.6	23.3	23.6	23.6	23.3	23.3	23.8	24.1	24.8	24.8	24.6	24.3	23.9
Bicarbonate	155	154	155	155	154	154	157	159	164	164	162	160	158
Sodium plus potassium	8.9	8.8	8.9	8.9	8.8	8.8	9.0	9.1	9.4	9.4	9.3	9.2	9.1
Magnesium	9.1	9.0	9.1	9.1	9.0	9.0	9.2	9.3	9.6	9.6	9.5	9.5	9.2
Calcium	36.8	36.4	36.8	36.8	36.4	36.4	37.2	37.6	38.8	38.8	38.4	38.0	37.4
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.010	.010	.010	.010	.009
Silica	1.6	1.5	1.6	1.6	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Alkalinity	92	91	92	92	91	91	93	94	97	97	96	95	93.4

Year 1933

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.9	2.7	2.7	5.9	12.0	20.4	21.1	22.1	20.7	15.8	7.8	4.7	11.6
Total solids	181	179	179	177	179	177	181	182	184	184	184	184	181
Nitrate	.43	.42	.42	.42	.42	.42	.43	.43	.44	.44	.44	.44	.43
Chloride	21.1	20.9	20.9	20.6	20.9	20.6	21.1	21.3	21.5	21.5	21.5	21.5	21.1
Sulphate	24.3	24.1	24.1	23.8	24.1	23.8	24.3	24.6	24.8	24.8	24.8	24.8	24.4
Bicarbonate	160	159	159	157	159	157	160	162	164	164	164	164	161
Sodium plus potassium	9.2	9.1	9.1	9.0	9.1	9.0	9.2	9.3	9.4	9.4	9.4	9.4	9.2
Magnesium	9.4	9.3	9.3	9.2	9.3	9.2	9.4	9.5	9.6	9.6	9.6	9.6	9.4
Calcium	38.0	37.6	37.6	36.2	37.6	37.2	38.0	38.4	38.8	38.8	38.8	38.8	38.1
Iron	.010	.009	.009	.009	.009	.009	.010	.010	.010	.010	.010	.010	.010
Silica	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Alkalinity	95	94	94	93	94	93	95	96	97	97	97	97	95.2

Year 1934

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.0	1.8	2.9	5.1	11.8	16.6	21.4	22.7	20.5	16.1	9.8	5.6	11.4
Total solids	182	182	181	179	179	177	177	179	179	179	181	181	179
Nitrate	.43	.43	.43	.42	.42	.42	.42	.42	.42	.42	.43	.43	.42
Chloride	21.3	21.3	21.1	20.9	20.9	20.6	20.6	20.9	20.9	20.9	21.1	21.1	21.0
Sulphate	24.6	24.6	24.3	24.1	24.1	23.8	23.8	24.1	24.1	24.1	24.3	24.3	24.2
Bicarbonate	162	162	160	159	159	157	157	159	159	159	160	160	159
Sodium plus potassium	9.3	9.3	9.2	9.1	9.1	9.0	9.0	9.1	9.1	9.1	9.2	9.2	9.2
Magnesium	9.5	9.5	9.4	9.3	9.3	9.2	9.2	9.3	9.3	9.3	9.4	9.4	9.3
Calcium	38.4	38.4	38.0	37.6	37.6	37.2	37.2	37.6	37.6	37.6	38.0	38.0	37.8
Iron	.009	.009	.010	.009	.009	.009	.009	.009	.009	.009	.010	.010	.009
Silica	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Alkalinity	96	96	95	94	94	93	93	94	94	94	95	95	94.4

Year 1935

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.3	1.7	3.6	6.7	10.4	17.8	23.6	24.4	20.3	15.1	11.5	5.1	11.9
Total solids	181	181	181	181	179	175	175	177	179	179	179	177	178
Nitrate	.43	.43	.43	.43	.42	.41	.41	.42	.42	.42	.42	.42	.42
Chloride	21.1	21.1	21.1	21.1	20.9	20.4	20.4	20.6	20.9	20.9	20.9	20.6	20.8
Sulphate	24.3	24.3	24.3	24.3	24.1	23.6	23.6	23.8	24.1	24.1	24.1	23.8	24.0
Bicarbonate	160	160	160	160	159	155	155	157	159	159	159	157	158
Sodium plus potassium	9.2	9.2	9.2	9.2	9.1	8.9	8.9	9.0	9.1	9.1	9.1	9.0	9.1
Magnesium	9.4	9.4	9.4	9.4	9.3	9.1	9.1	9.2	9.3	9.3	9.3	9.2	9.3
Calcium	38.0	38.0	38.0	38.0	37.6	36.8	36.8	37.2	37.6	37.6	37.6	37.2	37.5
Iron	.010	.010	.010	.010	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Alkalinity	95	95	95	95	94	92	92	93	94	94	94	93	93.8

Year 1936

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.4	1.7	2.2	2.7	12.1	17.7	22.4	22.7	21.0	16.1	9.8	3.6	11.9
Total solids	175	175	177	179	177	177	177	179	179	182	182	182	178
Nitrate	.41	.41	.42	.42	.42	.42	.42	.42	.42	.43	.43	.43	.42
Chloride	20.4	20.4	20.6	20.9	20.6	20.6	20.6	20.9	20.9	21.3	21.3	21.3	20.8
Sulphate	23.6	23.6	23.8	24.1	23.8	23.8	23.8	24.1	24.1	24.6	24.6	24.6	24.0
Bicarbonate	155	155	157	159	157	157	157	159	159	162	162	162	158
Sodium plus potassium	8.9	8.9	9.0	9.1	9.0	9.0	9.0	9.1	9.1	9.3	9.3	9.3	9.1
Magnesium	9.1	9.1	9.2	9.3	9.2	9.2	9.2	9.3	9.3	9.5	9.5	9.5	9.3
Calcium	36.8	36.8	37.2	37.6	37.2	37.2	37.2	37.6	37.6	38.4	38.4	38.4	37.5
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.010	.010	.010	.009
Silica	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Alkalinity	92	92	93	94	93	93	93	94	94	96	96	96	93.8

Year 1937

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	4.1	2.6	2.3	6.5	11.7	17.3	22.3	23.9	20.3	14.4	9.2	3.5	11.5
Total solids	177	173	175	179	175	179	181	182	182	184	184	182	179
Nitrate	.42	.41	.41	.42	.41	.42	.43	.43	.43	.44	.44	.43	.43
Chloride	20.6	20.2	20.4	20.9	20.4	20.9	21.1	21.3	21.3	21.5	21.5	21.3	21.0
Sulphate	23.8	23.3	23.6	24.1	23.6	24.1	24.3	24.6	24.6	24.8	24.8	24.6	24.2
Bicarbonate	157	154	155	159	155	159	160	162	162	164	164	162	159
Sodium plus potassium	9.0	8.8	8.9	9.1	8.9	9.1	9.2	9.3	9.3	9.4	9.4	9.3	9.2
Magnesium	9.2	9.0	9.1	9.3	9.1	9.3	9.4	9.5	9.5	9.6	9.6	9.5	9.3
Calcium	37.2	36.4	36.8	37.6	36.8	37.6	38.0	38.4	38.4	38.8	38.8	38.4	37.8
Iron	.009	.009	.009	.009	.009	.009	.010	.010	.010	.010	.010	.010	.009
Silica	1.6	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Alkalinity	93	91	92	94	92	94	95	96	96	97	97	96	94.4

Year 1938

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.7	3.3	3.8	8.4	13.3	18.1	22.1	25.2	20.5	16.6	11.3	5.1	12.5
Total solids	179	177	175	167	171	173	177	175	179	181	181	182	176
Nitrate	.42	.42	.41	.40	.40	.41	.42	.41	.42	.43	.43	.43	.42
Chloride	20.9	20.6	20.4	19.5	20.0	20.2	20.6	20.4	20.9	21.1	21.1	21.3	20.6
Sulphate	24.1	23.8	23.6	22.5	23.0	23.3	23.8	23.6	24.1	24.3	24.3	24.6	23.8
Bicarbonate	159	157	155	149	152	154	157	155	159	160	160	162	157
Sodium plus potassium	9.1	9.0	8.9	8.5	8.7	8.8	9.0	8.9	9.1	9.2	9.2	9.3	9.0
Magnesium	9.3	9.2	9.1	8.7	8.9	9.0	9.2	9.1	9.3	9.4	9.4	9.5	9.2
Calcium	37.6	37.2	36.8	35.2	36.0	36.4	37.2	36.8	37.6	38.0	38.0	38.4	37.1
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.010	.010	.010	.009
Silica	1.6	1.6	1.6	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Alkalinity	94	93	92	88	90	91	93	92	94	95	95	96	92.8

Year 1939

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.8	2.3	2.6	5.3	11.7	18.2	20.9	23.6	21.0	16.3	9.8	6.3	11.7
Total solids	181	177	165	167	169	175	175	175	173	173	173	175	173
Nitrate	.43	.42	.39	.40	.40	.41	.41	.41	.41	.41	.41	.41	.41
Chloride	21.1	20.6	19.3	19.5	19.8	20.4	20.4	20.4	20.2	20.2	20.2	20.4	20.2
Sulphate	24.3	23.8	22.3	22.5	22.8	23.6	23.6	23.6	23.3	23.3	23.3	23.6	23.3
Bicarbonate	160	157	147	149	150	155	155	155	154	154	154	155	154
Sodium plus potassium	9.2	9.0	8.4	8.5	8.6	8.9	8.9	8.9	8.8	8.8	8.8	8.9	8.8
Magnesium	9.4	9.2	8.6	8.7	8.8	9.1	9.1	9.1	9.0	9.0	9.0	9.1	9.0
Calcium	38.0	37.2	34.8	35.2	35.6	36.8	36.8	36.8	36.4	36.4	36.4	36.8	36.4
Iron	.010	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.6	1.6	1.5	1.5	1.5	1.6	1.6	1.6	1.5	1.5	1.5	1.6	1.5
Alkalinity	95	93	87	88	89	92	92	92	91	91	91	92	91.1

Year 1940

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.1	2.2	2.0	3.1	9.2	15.7	21.4	21.5	20.0	15.8	10.2	4.9	10.7
Total solids	173	171	171	171	169	171	173	173	175	173	173	171	172
Nitrate	.41	.40	.40	.40	.40	.40	.41	.41	.41	.41	.41	.40	.41
Chloride	20.2	20.0	20.0	20.0	19.8	20.0	20.2	20.2	20.4	20.2	20.2	20.0	20.1
Sulphate	23.3	23.0	23.0	23.0	22.8	23.0	23.3	23.3	23.6	23.3	23.3	23.0	23.2
Bicarbonate	154	152	152	152	150	152	154	154	155	154	154	152	153
Sodium plus potassium	8.8	8.7	8.7	8.7	8.6	8.7	8.8	8.8	8.9	8.8	8.8	8.7	8.8
Magnesium	9.0	8.9	8.9	8.9	8.8	8.9	9.0	9.0	9.1	9.0	9.0	8.9	9.0
Calcium	36.4	36.0	36.0	36.0	35.6	36.0	36.4	36.4	36.8	36.4	36.4	36.0	36.2
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.5	1.5	1.5	1.5
Alkalinity	91	90	90	90	89	90	91	91	92	91	91	90	90.5

Year 1941

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.9	2.1	2.4	5.0	12.0	16.7	20.7	22.7	20.8	16.5	9.9	6.1	11.5
Total solids	171	173	171	173	169	171	173	173	171	173	173	173	172
Nitrate	.40	.41	.40	.41	.40	.40	.41	.41	.40	.41	.41	.41	.41
Chloride	20.0	20.2	20.0	20.2	19.8	20.0	20.2	20.2	20.0	20.2	20.2	20.2	20.1
Sulphate	23.0	23.3	23.0	23.3	22.8	23.0	23.3	23.3	23.0	23.3	23.3	23.3	23.2
Bicarbonate	152	154	152	154	150	152	154	154	152	154	154	154	153
Sodium plus potassium	8.7	8.8	8.7	8.8	8.6	8.7	8.8	8.8	8.7	8.8	8.8	8.8	8.8
Magnesium	8.9	9.0	8.9	9.0	8.8	8.9	9.0	9.0	8.9	9.0	9.0	9.0	9.0
Calcium	36.0	36.4	36.0	36.4	35.6	36.0	36.4	36.4	36.0	36.4	36.4	36.4	36.2
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Alkalinity	90	91	90	91	89	90	91	91	90	91	91	91	90.5

Year 1942

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.1	1.8	2.6	7.4	12.6	14.6	21.9	22.8	20.9	15.4	9.9	3.6	11.3
Total solids	171	173	171	169	173	173	173	173	173	173	175	175	173
Nitrate	.40	.41	.40	.40	.41	.41	.41	.41	.41	.41	.41	.41	.41
Chloride	20.0	20.2	20.0	19.8	20.2	20.2	20.2	20.2	20.2	20.2	20.4	20.4	20.2
Sulphate	23.0	23.3	23.0	22.8	23.3	23.3	23.3	23.3	23.3	23.3	23.6	23.6	23.2
Bicarbonate	152	154	152	150	154	154	154	154	154	154	155	155	153
Sodium plus potassium	8.7	8.8	8.7	8.6	8.8	8.8	8.8	8.8	8.8	8.8	8.9	8.9	8.8
Magnesium	8.9	9.0	8.9	8.8	9.0	9.0	9.0	9.0	9.0	9.0	9.1	9.1	9.0
Calcium	36.0	36.4	36.0	35.6	36.4	36.4	36.4	36.4	36.4	36.4	36.8	36.8	36.3
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.5
Alkalinity	90	91	90	89	91	91	91	91	91	91	92	92	90.8

Year 1943

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	1.8	1.7	1.8	4.9	9.8	16.4	21.3	23.6	20.1	14.9	9.2	4.3	10.8
Total solids	173	173	173	175	175	175	177	177	177	177	181	181	176
Nitrate	.41	.41	.41	.41	.41	.41	.42	.42	.42	.42	.43	.43	.42
Chloride	20.2	20.2	20.2	20.4	20.4	20.4	20.6	20.6	20.6	20.6	21.1	21.1	20.1
Sulphate	23.3	23.3	23.3	23.6	23.6	23.6	23.8	23.8	23.8	23.8	24.3	24.3	23.7
Bicarbonate	154	154	154	155	155	155	157	157	157	157	160	160	156
Sodium plus potassium	8.8	8.8	8.8	8.9	8.9	8.9	9.0	9.0	9.0	9.0	9.2	9.2	9.0
Magnesium	9.0	9.0	9.0	9.1	9.1	9.1	9.2	9.2	9.2	9.2	9.4	9.4	9.2
Calcium	36.4	36.4	36.4	36.8	36.8	36.8	37.2	37.2	37.2	37.2	38.0	38.0	37.0
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.010	.010	.009
Silica	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Alkalinity	91	91	91	92	92	92	93	93	93	93	95	95	92.6

Year 1944

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.1	1.9	2.2	4.3	10.0	16.7	21.6	21.4	20.0	16.0	11.1	4.9	11.0
Total solids	182	182	177	169	182	184	184	184	186	184	186	182	182
Nitrate	.43	.43	.42	.40	.43	.44	.44	.44	.44	.44	.44	.43	.43
Chloride	21.3	21.3	20.6	19.8	21.3	21.5	21.5	21.5	21.8	21.5	21.8	21.3	21.3
Sulphate	24.6	24.6	23.8	22.8	24.6	24.8	24.8	24.8	25.1	24.8	25.1	24.6	24.5
Bicarbonate	162	162	157	150	162	164	164	164	166	164	166	162	162
Sodium plus potassium	9.3	9.3	9.0	8.6	9.3	9.4	9.4	9.4	9.5	9.4	9.5	9.3	9.3
Magnesium	9.5	9.5	9.2	8.8	9.5	9.6	9.6	9.6	9.7	9.6	9.7	9.5	9.5
Calcium	38.4	38.4	37.2	35.6	38.4	38.8	38.8	38.8	39.2	38.8	39.2	38.4	38.3
Iron	.010	.010	.009	.009	.010	.010	.010	.010	.010	.010	.010	.010	.010
Silica	1.6	1.6	1.6	1.5	1.6	1.6	1.6	1.6	1.7	1.6	1.7	1.6	1.6
Alkalinity	96	96	93	89	96	97	97	97	98	97	98	96	95.8

Year 1945

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	1.9	1.9	2.8	9.6	11.4	14.9	20.3	22.3	20.7	15.3	11.2	4.8	11.4
Total solids	184	184	171	169	171	169	175	181	182	182	184	184	178
Nitrate	.44	.44	.40	.40	.40	.40	.41	.43	.43	.43	.44	.44	.42
Chloride	21.5	21.5	20.0	19.8	20.0	19.8	20.4	21.1	21.3	21.3	21.5	21.5	20.8
Sulphate	24.8	24.8	23.0	22.8	23.0	22.8	23.6	24.3	24.6	24.6	24.8	24.8	24.0
Bicarbonate	164	164	152	150	152	150	155	160	162	162	164	164	158
Sodium plus potassium	9.4	9.4	8.7	8.6	8.7	8.6	8.9	9.2	9.3	9.3	9.4	9.4	9.1
Magnesium	9.6	9.6	8.9	8.8	8.9	8.8	9.1	9.4	9.5	9.5	9.6	9.6	9.3
Calcium	38.8	38.8	36.0	35.6	36.0	35.6	36.8	38.0	38.4	38.4	38.8	38.8	37.5
Iron	.010	.010	.009	.009	.009	.009	.009	.010	.010	.010	.010	.010	.009
Silica	1.6	1.6	1.5	1.5	1.5	1.5	1.6	1.5	1.5	1.5	1.6	1.6	1.6
Alkalinity	97	97	90	89	90	89	92	95	96	96	97	97	93.8

Year 1946

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.2	1.9	3.6	8.3	12.0	16.3	19.7	21.3	19.6	16.8	12.8	6.1	11.7
Total Solids	184	182	177	167	167	169	171	173	171	173	177	171	173
Nitrate	.44	.43	.42	.40	.40	.40	.40	.41	.40	.41	.42	.40	.41
Chloride	21.5	21.3	20.6	19.5	19.5	19.8	20.0	20.2	20.0	20.2	20.6	20.0	20.3
Sulphate	24.8	24.6	23.8	22.5	22.5	22.8	23.0	23.3	23.0	23.3	23.8	23.0	23.4
Bicarbonate	164	162	157	149	149	150	152	154	152	154	157	152	154
Sodium plus potassium	9.4	9.3	9.0	8.5	8.5	8.6	8.7	8.8	8.7	8.8	9.0	8.7	8.9
Magnesium	9.6	9.5	9.2	8.7	8.7	8.8	8.9	9.0	8.9	9.0	9.2	8.9	9.0
Calcium	38.8	38.4	37.2	35.2	35.2	35.6	36.0	36.4	36.0	36.4	37.2	36.0	36.5
Iron	.010	.010	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.6	1.6	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.5	1.6
Alkalinity	97	96	93	88	88	89	90	91	90	91	93	90	91.3

Year 1947

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.8	2.2	2.4	4.2	10.7	15.8	18.8	22.2	22.3	17.7	12.3	4.8	11.4
Total solids	169	165	171	165	163	171	171	165	165	165	165	167	167
Nitrate	.40	.39	.40	.39	.39	.40	.40	.39	.39	.39	.39	.40	.40
Chloride	19.8	19.3	20.0	19.3	19.1	20.0	20.0	19.3	19.3	19.3	19.3	19.5	19.5
Sulphate	22.8	22.3	23.0	22.3	22.0	23.0	23.0	22.3	22.3	22.3	22.3	22.5	22.5
Bicarbonate	150	147	152	147	145	152	152	147	147	147	147	149	148
Sodium plus potassium	8.6	8.4	8.7	8.4	8.3	8.7	8.7	8.4	8.4	8.4	8.4	8.5	8.5
Magnesium	8.8	8.6	8.9	8.6	8.5	8.9	8.9	8.6	8.6	8.6	8.6	8.7	8.7
Calcium	35.6	34.8	36.0	34.8	34.4	36.0	36.0	34.8	34.8	34.8	34.8	35.2	35.2
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Alkalinity	89	87	90	87	86	90	90	87	87	87	87	88	87.9

Year 1948

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.1	2.0	3.3	8.2	11.8	16.5	20.2	22.7	22.7	15.6	11.3	6.4	11.9
Total solids	175	171	167	167	163	169	169	171	171	173	173	173	170
Nitrate	.41	.40	.40	.40	.39	.40	.40	.40	.40	.40	.40	.40	.40
Chloride	20.4	20.0	19.5	19.5	19.1	19.8	19.8	20.0	20.0	20.2	20.2	20.2	19.9
Sulphate	23.6	23.0	22.5	22.5	22.0	22.8	22.8	23.0	23.0	23.3	23.3	23.3	22.9
Bicarbonate	155	152	149	149	145	150	150	152	152	154	154	154	151
Sodium plus potassium	8.9	8.7	8.5	8.5	8.3	8.6	8.7	8.7	8.7	8.8	8.8	8.8	8.7
Magnesium	9.1	8.9	8.7	8.7	8.5	8.8	8.8	8.9	8.9	9.0	9.0	9.0	8.8
Calcium	36.8	36.0	35.2	35.2	34.4	35.6	35.6	36.0	36.0	36.4	36.4	36.4	35.8
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.6	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Alkalinity	92	90	88	88	86	89	89	90	90	91	91	91	89.5

Year 1949

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	3.2	2.3	3.0	6.8	11.9	18.4	20.1	24.3	18.6	17.2	11.7	4.4	11.8
Total solids	171	169	167	167	173	175	173	173	175	175	175	175	172
Nitrate	.40	.40	.40	.40	.41	.41	.41	.41	.41	.41	.41	.41	.41
Chloride	20.0	19.8	19.5	19.5	20.2	20.4	20.2	20.2	20.4	20.4	20.4	20.4	20.1
Sulphate	23.0	22.8	22.5	22.5	23.3	23.6	23.3	23.3	23.6	23.6	23.6	23.6	23.2
Bicarbonate	152	150	149	149	154	155	154	154	155	155	155	155	153
Sodium plus potassium	8.7	8.6	8.5	8.5	8.8	8.9	8.8	8.8	8.9	8.9	8.9	8.9	8.8
Magnesium	8.9	8.8	8.7	8.7	9.0	9.1	9.0	9.0	9.1	9.1	9.1	9.1	9.0
Calcium	36.0	35.6	35.2	35.2	36.4	36.8	36.4	36.4	36.8	36.8	36.8	36.8	36.3
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.5	1.5	1.5	1.5	1.5	1.6	1.5	1.5	1.6	1.6	1.6	1.6	1.5
Alkalinity	90	89	88	88	91	92	91	91	92	92	92	92	90.7

Year 1950

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	5.3	3.1	2.6	4.9	9.6	16.8	20.3	22.5	17.9	16.2	10.9	3.9	11.2
Total solids	171	171	171	169	167	169	169	169	169	175	173	171	170
Nitrate	.40	.40	.40	.40	.40	.40	.40	.40	.40	.41	.41	.40	.40
Chloride	20.0	20.0	20.0	19.8	19.5	19.8	19.8	19.8	19.8	20.4	20.2	20.0	19.9
Sulphate	23.0	23.0	23.0	22.8	22.5	22.8	22.8	22.8	22.8	23.6	23.3	23.0	23.0
Bicarbonate	152	152	152	150	149	150	150	150	150	155	154	152	152
Sodium plus potassium	8.7	8.7	8.7	8.6	8.5	8.6	8.6	8.6	8.6	8.9	8.8	8.7	8.7
Magnesium	8.9	8.9	8.9	8.8	8.7	8.8	8.8	8.8	8.8	9.1	9.0	8.9	8.9
Calcium	36.0	36.0	36.0	35.6	35.2	35.6	35.6	35.6	35.6	36.8	36.4	36.0	35.9
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.5	1.5	1.5
Alkalinity	90	90	90	89	88	89	89	89	89	92	91	90	89.7

Year 1951

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.4	1.8	2.2	6.5	11.2	15.7	21.6	22.8	20.3	15.2	9.6	4.5	11.1
Total solids	169	167	169	173	169	173	167	171	171	171	171	171	170
Nitrate	.40	.40	.40	.41	.40	.41	.40	.40	.40	.40	.40	.40	.40
Chloride	19.8	19.5	19.8	20.2	19.8	20.2	19.5	20.0	20.0	20.0	20.0	20.0	19.9
Sulphate	22.8	22.5	22.8	23.3	22.8	23.3	22.5	23.0	23.0	23.0	23.0	23.0	22.9
Bicarbonate	150	149	150	154	150	154	149	152	152	152	152	152	151
Sodium plus potassium	8.6	8.5	8.6	8.8	8.6	8.8	8.5	8.7	8.7	8.7	8.7	8.7	8.7
Magnesium	8.8	8.7	8.8	9.0	8.8	9.0	8.7	8.9	8.9	8.9	8.9	8.9	8.9
Calcium	35.6	35.2	35.6	36.4	35.6	36.4	36.2	36.0	36.0	36.0	36.0	36.0	35.8
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Alkalinity	89	88	89	91	89	91	88	90	90	90	90	90	89.6

Year 1952

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.6	2.6	3.1	6.2	5.6	17.1	22.2	22.8	20.6	14.6	10.6	5.3	11.1
Total solids	169	169	171	167	165	165	169	169	169	167	165	165	168
Nitrate	.40	.40	.40	.40	.39	.39	.40	.40	.40	.40	.39	.39	.40
Chloride	19.8	19.8	20.0	22.5	22.3	22.3	22.8	22.8	22.8	22.5	22.3	22.3	22.6
Bicarbonate	150	150	152	149	147	147	150	150	150	149	147	147	149
Sodium plus potassium	8.6	8.6	8.7	8.5	8.4	8.4	8.6	8.6	8.6	8.5	8.4	8.4	8.6
Magnesium	8.8	8.8	8.9	8.7	8.6	8.6	8.8	8.8	8.8	8.7	8.6	8.6	8.7
Calcium	35.6	35.6	36.0	35.2	34.8	34.8	35.6	35.6	35.6	35.2	34.8	34.8	35.3
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Alkalinity	89	89	90	88	87	87	89	89	89	88	87	87	88.3

Year 1953

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	2.9	2.1	3.8	7.3	10.7	16.2	21.6	22.6	20.7	16.2	11.8	6.8	11.9
Total solids	165	163	165	163	173	175	173	181	181	181	181	175	173
Nitrate	.39	.39	.39	.39	.41	.41	.41	.43	.43	.43	.43	.41	.41
Chloride	19.3	19.1	19.3	19.1	20.2	20.4	20.2	21.1	21.1	21.1	21.1	20.4	20.2
Sulphate	22.3	22.0	22.3	22.0	23.3	23.6	23.3	24.3	24.3	24.3	24.3	23.6	23.3
Bicarbonate	147	145	147	145	154	155	154	160	160	160	160	155	154
Sodium plus potassium	8.4	8.3	8.4	8.3	8.8	8.9	8.8	9.2	9.2	9.2	9.2	8.9	8.8
Magnesium	8.6	8.5	8.6	8.6	9.0	9.1	9.0	9.4	9.4	9.4	9.4	9.1	9.0
Calcium	34.8	34.4	34.8	34.4	36.4	36.8	36.4	38.0	38.0	38.0	38.0	36.8	36.4
Iron	.009	.009	.009	.009	.009	.009	.009	.010	.010	.010	.010	.009	.009
Silica	1.5	1.5	1.5	1.5	1.5	1.6	1.5	1.6	1.6	1.6	1.6	1.6	1.5
Alkalinity	87	86	87	86	91	92	91	95	95	95	95	92	91.0

Year 1954

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	3.3	2.8	3.9	6.9	12.4	18.0	22.1	23.5	20.4	17.0	11.4	6.4	12.3
Total solids	171	169	165	169	162	167	165	167	165	165	165	165	166
Nitrate	.40	.40	.39	.39	.38	.40	.39	.40	.39	.39	.39	.39	.39
Chloride	20.0	19.8	19.3	19.8	18.9	19.5	19.3	19.5	19.3	19.3	19.3	19.3	19.4
Sulphate	23.0	22.8	22.3	22.8	21.8	22.5	22.3	22.5	22.3	22.3	22.3	22.3	22.4
Bicarbonate	152	150	147	150	144	149	147	149	147	147	147	147	148
Sodium plus potassium	8.7	8.6	8.4	8.6	8.2	8.5	8.4	8.5	8.4	8.4	8.4	8.4	8.5
Magnesium	8.9	8.9	8.6	8.8	8.4	8.7	8.6	8.7	8.6	8.6	8.6	8.6	8.7
Calcium	36.0	35.6	34.8	35.6	34.0	35.2	34.8	35.2	34.8	34.8	34.8	34.8	35.0
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.5	1.5	1.5	1.5	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Alkalinity	90	89	87	89	85	88	87	88	87	87	87	87	87.6

Year 1955

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	3.3	2.1	3.0	8.2	13.6	17.8	21.6	22.1	20.7	16.5	9.1	2.8	11.7
Total solids	160	165	163	163	163	165	163	165	167	163	162	162	164
Nitrate	.38	.39	.39	.39	.39	.39	.39	.39	.40	.39	.38	.38	.39
Chloride	18.6	19.3	19.1	19.1	19.1	19.3	19.1	19.3	19.5	19.1	18.9	18.9	19.1
Sulphate	21.5	22.3	22.0	22.0	22.0	22.3	22.0	22.3	22.5	22.0	21.8	21.8	22.0
Bicarbonate	142	147	145	145	145	147	145	147	149	145	144	144	145
Sodium plus potassium	8.1	8.4	8.3	8.3	8.3	8.4	8.3	8.4	8.5	8.3	8.2	8.2	8.4
Magnesium	8.3	8.6	8.5	8.5	8.5	8.6	8.5	8.6	8.7	8.5	8.4	8.4	8.5
Calcium	33.6	34.8	34.4	34.4	34.4	34.8	34.4	34.8	35.2	34.4	34.0	34.0	34.4
Iron	.008	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.4	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.4	1.4	1.5
Alkalinity	84	87	86	86	86	87	86	87	88	86	85	85	86.1

Year 1956

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Av.
Temp.	1.8	1.1	1.5	4.6	10.5	15.9	19.8	21.9	19.8	15.1	10.9	4.9	10.7
Total solids	169	171	171	167	165	163	163	163	169	171	169	169	168
Nitrate	.40	.40	.40	.40	.39	.39	.39	.39	.40	.40	.40	.40	.40
Chloride	19.8	20.0	20.0	19.5	19.3	19.1	19.1	19.1	19.8	20.0	19.8	19.8	19.6
Sulphate	22.8	23.0	23.0	22.5	22.3	22.0	22.0	22.0	22.8	23.0	22.8	22.8	22.6
Bicarbonate	150	152	152	149	147	145	145	145	150	152	150	150	149
Sodium plus potassium	8.6	8.7	8.7	8.5	8.4	8.3	8.3	8.3	8.6	8.7	8.6	8.6	8.6
Magnesium	8.8	8.9	8.9	8.7	8.6	8.5	8.5	8.5	8.8	8.9	8.8	8.8	8.7
Calcium	35.6	36.0	36.0	35.2	34.8	34.4	34.4	34.4	35.6	36.0	35.6	35.6	35.3
Iron	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009	.009
Silica	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Alkalinity	89	90	90	88	87	86	86	86	89	90	89	89	88.3

APPENDIX II

LIMNOLOGICAL OBSERVATIONS

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1947 and 1948
STATION I (42°12.0', 81°54.0')

Depth in Feet	1947								1948							
	8/8	8/13	8/21	8/28	9/14	9/27	10/17	12/3	4/15	4/23	5/6	7/8'	7/20	7/28	8/6	9/9
Water Temperature, °C																
Surface	23.8	25.0	26.8	25.9	23.7	16.4	18.3	6.0	3.0	4.7	10.0	19.3	23.5	20.7	18.3	22.0
15	23.2	24.2	25.7	25.6	23.7	16.3	17.3							19.7	18.1	
30	14.5	18.6	22.9	25.2	22.9	16.3	17.1	6.2				13.6	18.9	11.3	17.9	
Bottom	12.7	13.6	15.1	14.3	13.6	16.2	15.7	6.4	3.6	4.0	8.0		12.2	11.0	.17.6	22.0
Dissolved Oxygen, ppm																
Surface	6.1	7.2	6.3	6.7	7.2	8.0	8.8		14.6	11.6	10.6		8.2	7.7	8.0	8.6
30	7.2	7.5				8.5	8.3							4.2	7.9	8.1
Bottom	7.1		6.1	6.0	6.7	6.3	7.7		14.6	11.5	11.6		4.2	4.1	5.6	7.3
Free Carbon Dioxide, ppm																
Surface									0.0	0.0	0.0		0.0	8.8	0.0	0.0
30					2.2								1.8	17.6	8.8	0.0
Bottom				3.5	1.5	2.6	0.8		0.0	0.0			1.3	17.6	17.6	0.0
Methyl Orange Alkalinity, ppm $CaCO_3$																
Surface			58	95	94	100	100	56	104	100	102		100	109	84	103
30					104	100	100						107	111	115	105
Bottom			58		110	96	100	57	104	100			112	115	114	124
Phenolphthalein Alkalinity, ppm $CaCO_3$																
Surface					3.0			1.6	4.0	4.0	5.0		0.0	0.0	8.0	6.0
30													0.0	0.0	0.0	3.0
Bottom									4.0	4.0			0.0	0.0	0.0	3.0
pH																
Surface	8.2	8.0	8.1	8.1	7.7	7.8	8.2		7.7	8.0	8.1		8.2	8.0	8.0	8.5
30		7.7	7.6		7.7	7.8	7.9						8.0	7.9	8.0	8.5
Bottom	7.4	7.6	7.8	7.3	7.4	7.8	7.8		7.8	8.1			7.6	8.0	8.0	8.5
Secchi Disc, feet																
	23	25			13											

1949, 1950, and 1951
STATION 1 (42°12.0', 81°54.0')

Depth in Feet	1949					1950					1951					
	6/19	7/12	7/20	8/4	8/23	5/29	6/7	8/26	9/1	11/5	5/30	6/28	7/13	7/18	8/2	8/28
Water Temperature, °C																
Surface	20.1	24.0	27.8	24.7	23.3	15.2	16.3	20.2	23.3	11.5	13.0	19.7	20.1	21.4	23.5	21.7
15	18.8	23.8	24.2	24.6	23.2	11.9	12.2						19.0	21.3		
30	17.1		23.8	23.9	22.9	10.0	8.1	20.0	21.9		11.3	17.0	18.7	17.5	23.3	21.3
Bottom	16.1	23.4	14.6	22.5	22.7	9.0	8.0	10.8	11.2	11.5	9.7	15.2	10.8	11.9	10.8	11.3
Dissolved Oxygen, ppm																
Surface	9.6	8.1	7.6		8.3	11.7	11.0	8.4		9.7	11.2	9.6		9.2		9.3
30	9.5	8.4	8.0		8.0	11.6	11.0	8.4			10.8	10.7		9.3		8.9
Bottom	8.0	7.9	6.4		7.9	10.9	10.8	7.6		9.6	10.8	9.3		8.3		4.5
Free Carbon Dioxide, ppm																
Surface	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.8	5.3		1.8		0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0			3.5		2.6		0.0
Bottom	0.0	2.0	3.0	2.5	0.0	0.9	1.3	2.6	2.6	0.0	7.1	7.0		4.0		2.7
Methyl Orange Alkalinity, ppm $CaCO_3$																
Surface	108	90	116	114	116	111	98	106	103	105	108	107		108		105
30	104	110	114	110	116	122	110	106	104			109		108		102
Bottom	100	106	114	114	116	116	112	114	107	100	120	108		109		110
Phenolphthalein Alkalinity, ppm $CaCO_3$																
Surface	4.0	4.0	5.0	5.0	5.0	3.0	1.0	2.0	2.5	2.5	0.0	0.0	0.0	0.0		3.0
30	4.0	2.0	3.0	4.0	4.0	0.5	0.0	1.0	2.0			0.0		0.0		2.0
Bottom	2.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0		0.0		0.0
pH																
Surface	8.0	8.1	8.3	8.2	8.5	8.0	8.1	8.2	8.4	8.2	7.8	8.1		8.0		8.4
30	7.9	8.1	8.0	8.1	8.5	8.0	8.0	8.0	8.4			8.1		7.9		8.3
Bottom	7.8	7.9	7.8	7.7		7.8	7.8	7.5	7.5	8.1	7.8	7.7		7.5		7.9
Secchi Disc, feet																
		11	15								18					

1952
STATION 1 (42°12.0', 81°54.0')

Depth in Feet	6/4	6/12	6/17	6/27	7/5	7/7	7/14	7/16	7/22	7/24	7/29	8/7	8/19	8/30	9/5
							1952								
Water Temperature, °C															
Surface	14.7	11.7	19.3	18.3	21.9	21.9	23.4	22.9	24.3	20.3	24.1	23.4	23.3	23.6	21.5
15	13.9	10.8	16.4	17.9	21.1	21.2	23.2	21.8	22.5	20.1	23.2	23.0	23.1	23.3	20.6
30	13.0	10.5	13.0	15.5	19.9	20.2	21.3	19.6	11.9	11.4	22.2	22.5	22.6	22.9	19.7
Bottom	9.9	10.5	10.5	12.7	12.7	13.0	10.8	11.0	10.2	10.2	10.8	11.4	16.1	12.5	12.6
Dissolved Oxygen, ppm															
Surface	9.2	10.1	6.2	8.9	8.5		7.4		7.9	7.8	8.0	8.7	8.7	9.6	9.7
30	9.7	8.6	10.4	9.0	8.7		8.0	7.8	7.6	7.8	7.8	8.6	8.5	9.4	9.2
Bottom	7.8	9.9	9.7	8.8	7.5		7.0	6.9	7.7	6.9	7.0	8.4	8.4	6.7	8.6
Free Carbon Dioxide, ppm															
Surface	3.2	3.3	2.0	0.0	0.0		0.0	1.0	2.3	4.3	0.0		0.0	0.0	4.0
30	2.0	3.0	1.3	1.3	0.0		2.0	3.3	2.0	2.6	2.0	0.0	0.0	0.0	5.3
Bottom	2.0	2.0	1.7	2.0	2.3		3.0	2.6	5.0	4.3	3.6	0.0	0.0	3.6	6.9
Methyl Orange Alkalinity, ppm $CaCO_3$															
Surface	114	114	118	117	105		103	103	108	96	98	105	102	105	99
30	110	118	114	111	106		109	97	109	101	98	99	109	108	91
Bottom	112	116	110	109	115		123	69	108	102	109	99	101	113	94
Phenolphthalein Alkalinity, ppm $CaCO_3$															
Surface	0.0	0.0	0.0	0.0	1.5		3.0	0.0	0.0	0.0	1.5	0.0	7.5	4.5	0.0
30	0.0	0.0	0.0	0.0	2.5		0.0	0.0	0.0	0.0	0.0		8.0	5.0	0.0
Bottom	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0		7.0	0.0	0.0
pH															
Surface	8.1	7.8	8.2	8.0	8.0		8.2	8.0	8.0	7.3	7.7	8.3	8.4	8.4	7.8
30	7.9	7.6	8.0	8.2	8.2		8.1	7.9	7.8	7.8	8.2	8.0	8.2		7.8
Bottom	7.8	7.7	7.7	7.9	7.9		7.9	7.0	7.7	7.4	7.5	8.3	8.2	8.0	7.8

1953
STATION 1 (42°12.0', 81°54.0')

Depth in Feet	1953														
	6/2	6/10	6/15	6/29	7/3	7/9	7/15	7/30	8/6	8/13	8/24	8/25	8/31	9/1	9/8	9/14
							Water Temperature, °C									
Surface	13.5	15.4	16.0	21.0	18.4	20.7	23.6	22.8	22.4	23.1	23.3	23.9	25.3	26.3	21.5	17.1
15	12.5	14.7	15.4	19.8	17.4	19.1	23.4	22.8	22.4	22.5	23.0	23.3		25.4	21.5	16.9
30	12.0	14.0	14.8	18.8	16.2	14.2	20.3	16.2	22.2	22.5	22.8	23.0	22.9	23.5	21.5	16.7
Bottom	11.8	10.6	11.4	11.8	11.4	11.3	11.5	11.1	20.4	14.5	12.6	12.7	12.7	13.5	13.2	15.3
							Dissolved Oxygen, ppm									
Surface	10.5	9.4	9.6	8.9	8.9	8.9	8.7	8.6	8.3	8.7	8.6	8.6	7.9	8.3	7.5	6.5
30	10.2	9.7	9.1	9.0	8.2	8.7	8.4	7.1	10.3	8.4	8.4		8.0		7.5	6.1
Bottom	9.2	9.8	9.1	8.8	8.4	8.4	7.5	7.2	10.8	5.2	3.5	3.2	2.2	2.0	2.4	5.1
							Free Carbon Dioxide, ppm									
Surface	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0
30		0.0	0.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0		0.0		1.0	3.0
Bottom	0.0	0.0	0.0	0.0	0.0	2.0	4.0	3.0	0.0	3.0	0.7	5.5	0.5	6.0	7.0	4.0
							Phenolphthalein Alkalinity, ppm $CaCO_3$									
Surface	8.0	5.0	5.0	2.8	2.7	2.0	3.0	4.0	4.8	4.5	5.0	5.5	4.0	4.2	0.8	0.0
30		2.5	2.5	2.0	1.8	0.0	1.5	0.0	3.2	5.5	2.7		3.3		0.0	0.0
Bottom	8.0	2.5	2.5	0.7	1.1	0.0	1.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
							pH									
Surface	8.0	7.8	8.0	8.0	8.1	8.0			8.4	8.4	8.4	8.4	8.4	8.4	7.8	7.5
30	8.2	7.8	7.9	8.1	8.0	7.6			8.4	8.4	8.4		8.4		7.8	7.5
Bottom	8.1	7.8	7.8	7.6	8.0	7.8			7.8	7.6	7.5	7.6	7.4	7.5	7.5	7.4
							Secchi Disc, feet									
	2	12	26	27	27	16	21	14	10	26	34	31	15		13	7

1947 and 1948
STATION 2 (42° 07.2', 81° 53.9')

Depth in Feet	1947						1948								
	7/28	8/8	8/13	8/21	9/13	9/27	4/23	6/4	6/19	7/8	7/31	8/13	8/26	8/30	9/9
Water Temperature, °C															
Surface	22.1	24.1	25.0	26.8	23.8	17.3	4.6	14.7	15.5	18.6	22.7	20.9	25.1	24.4	22.7
30	20.9	17.2	23.4	18.8	23.7	16.9	4.4	10.7	14.2	18.2	22.7		23.2	23.8	23.1
45	20.9	11.5	12.2	12.6	23.4	16.6				17.0	22.5	20.7	22.0	22.4	23.0
Bottom	10.5	11.0	10.8	11.9	12.7	14.5	4.4	10.2	12.6	11.0	11.3	11.1	11.4	15.2	17.0
Mean	18.6	16.9	18.3	19.0	21.2	16.4	4.5	11.7	14.8	17.2	22.1		21.0	23.1	21.6
Mean of Epilimnion	21.2	23.4	24.4	25.4	23.7					18.1	22.6		23.7	23.7	
Dissolved Oxygen, ppm															
Surface								9.8	11.0	9.4	8.2	8.2	7.5	7.9	8.0
30	8.5	7.0		7.4	7.3	6.3		9.8	11.2		8.1	8.2	8.0	3.1	8.0
45	7.9					6.5		7.7	10.2	9.5	8.0		6.2	3.1	8.1
Bottom		7.0		6.9						6.6	7.8	5.0			
Free Carbon Dioxide, ppm															
Surface				0.0	0.0				0.0		0.0	0.0	0.0	0.0	0.0
30					0.0				0.0		0.0	0.0	0.0	0.0	0.0
45					0.0				0.0		0.0	1.3	0.Q	0.0	0.0
Bottom					6.4				0.0	1.8	0.0	1.3	22.1	46.2	1.8
Methyl Orange Alkalinity, ppm Ca CO_3															
Surface				115	96	100		106	105	98	104	102	110	104	103
30					97	100			105		98	104	107	104	102
45				150		100			96	98	102	106	109	106	105
Bottom				150	100	100		107	117	106	98	108	117	106	93
Phenolphthalein Alkalinity, ppm $CaCO_3$															
Surface				1.5	3.0			5.0	4.0	2.4	4.0	4.0	9.0	7.0	4.0
30					3.0				14.0		3.0	2.0	11.0	6.0	6.0
45					3.0				4.0	3.6	3.6	0.0	2.0	3.0	6.0
Bottom					0.0			1.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
pH															
Surface	8.0	8.1		8.2	8.0	8.0		8.3	8.4	8.4	8.0	8.2	8.3	8.3	8.5
30	8.0				7.9	7.9			8.5		8.4	8.2	8.0	8.3	8.5
45		7.4		7.4					8.4	8.4	8.0	7.3	8.0	8.3	8.5
Bottom	7.5			7.3	7.4	7.4		7.9	8.3	7.7	8.0	7.4	7.2	7.3	7.5
Secchi Disc, feet															
	25	19	25		25	11									

1949
STATION 2 (42° 07.2', 81° 53.9')

Depth in Feet	1949											
	6/10	6/19	6/27	7/6	7/12	7/20	7/28	8/4	8/10	8/23	9/7	9/15
						Water Temperature, °C						
Surface	15.2	20.4	23.2	26.2	22.0	24.0	25.5	25.0	26.0	23.2	20.7	19.2
30	14.6	16.4	16.3	20.1	21.8	22.8	24.5	24.2	24.7	23.0	20.8	19.4
45	14.4	12.7	12.4	12.4	21.5	22.3	22.5	23.6	24.1	22.4	20.6	19.2
Bottom	11.3	11.1	10.0	11.2	12.2	12.4	11.4	12.5	12.0	12.5	19.4	18.4
Mean	14.3	15.9	16.5	19.4	20.4	21.1	21.6	22.3	22.9	21.3	20.0	19.2
Mean of Epilimnion			22.6	25.6	21.7	22.9	24.4	24.3	25.7	23.0		
						Dissolved Oxygen, ppm						
Surface	9.5	10.2	9.6	8.3	8.8	8.6	9.2	8.7	8.3	8.6	8.1	8.1
30		9.5	9.3	8.5	8.0	8.4	8.4	8.8	9.1	7.5	8.2	7.4
45		9.0	9.9	8.0	8.0	8.5	8.6	8.4	8.7	8.2	8.2	8.0
Bottom	10.0	9.0	9.1	7.6	7.0	6.0	6.0	4.5	5.1	2.4	8.1	6.4
						Free Carbon Dioxide, ppm						
Surface		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bottom		0.0	1.9	0.9	2.6	2.2	4.0	5.0	4.4	5.3	1.8	0.0
						Methyl Orange Alkalinity, ppm $CaCO_3$						
Surface		124	124	112	112	120	112	116	112	116	104	100
30		124	116	128	116	116	116	114	114	118	105	100
45		124	114	128	116	118	112	114	114	118	105	100
Bottom		120	111	96	114	112	116	110	108	114	104	100
						Phenolphthalein Alkalinity, ppm $CaCO_3$						
Surface		5.0	6.0	4.0	3.0	4.0	5.0	5.0	2.5	5.0	2.0	2.0
30		6.0	5.0	4.0	3.0	3.0	4.0	4.0	2.5	5.0	2.5	2.0
45		4.0	4.0	0.0	3.0	3.0	3.0	3.0	2.0	3.0	2.0	2.0
Bottom		5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
						pH						
Surface		7.8	8.0	8.1	8.2	8.3	8.2	8.3	8.3	8.5	8.4	8.4
30		7.9	8.1	8.2	8.2	8.2	8.2	8.2	8.2	8.5	8.3	8.1
45		7.8	8.0	7.8	8.0	8.2	8.0	8.2	8.2	8.2	8.2	8.1
Bottom		7.8	7.8	7.7	7.6	7.6	7.6	7.3	7.3	7.3	8.1	8.0
						Secchi Disc, feet						
	27	43	47	22	33	27	25					

1950
STATION 2 (42° 07.2', 81° 53.9')

Depth in Feet	1950											
	5/26	6/7	6/15	6/25	7/5	7/14	7/18	7/26	8/8	8/24	9/1	10/1
					Water Temperature, °C							
Surface	11.9	16.3	17.2	21.2	20.1	21.4	21.6	20.8	21.9	21.9	22.4	19.4
30	8.6	12.2	12.6	17.2	19.7	20.7	21.0	20.5	21.5	21.6	22.4	18.0
45	5.6	6.6	8.5	15.0	14.7	20.6	20.7	20.4	21.3	21.5	22.4	17.8
Bottom	5.4	6.5	6.6	10.3	10.4	11.3	10.2	10.3	10.0	12.4	12.7	17.5
Mean	8.1	10.9	12.5	16.6	17.4	19.6	19.2	19.2	19.1	21.1	21.6	18.2
Mean of Epilimnion		13.9	15.4	18.3	19.8	20.8	21.2	20.5	21.6	21.6	22.4	
					Dissolved Oxygen, ppm							
Surface	12.7	11.2	10.2	10.0	8.2	8.4		8.4	8.1	8.2	8.3	7.6
30		11.2	10.6	10.0	7.4	8.6		8.5	8.1	8.6	8.0	7.4
45		11.8		10.1	6.1	9.1		8.0	7.7	8.7	7.8	7.1
Bottom	12.0	11.8	10.1	9.4	6.9	7.6		7.3	6.1	3.8	3.8	7.1
					Free Carbon Dioxide, ppm							
Surface	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
30		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0
45		0.9	1.3		1.8	0.4		0.0	0.9	0.0	0.0	0.9
Bottom	0.9	1.3	0.9		4.4	4.4		1.8	3.5	6.6	6.2	0.9
					Methyl Orange Alkalinity, ppm $CaCO_3$							
Surface	112	110	102	117	110	104		111	101	105	103	101
30		105	97	112	108	103		110	102	103	102	100
45		120	100	118	110	109		108	102	103	104	102
Bottom	115	107	100	116	98	107		110	103	105	106	102
					Phenolphthalein Alkalinity, ppm $CaCO_3$							
Surface	3.0	1.0	2.0		2.0	1.0		3.0	2.5	3.0	2.5	2.0
30		1.5	2.0		1.0	1.0		3.0	2.5	3.0	2.5	1.0
45		0.0	0.0		0.0	0.0		2.0	0.0	2.0	2.5	0.0
Bottom	0.0	0.0	0.0		0.0	0.0		0.0	0.0	0.0	0.0	0.0
					pH							
Surface	8.1	8.1	8.2	8.2	8.0			8.2	8.4	8.4	8.4	8.1
30		8.2	8.2	8.2	8.0	8.2		8.2	8.4	8.4	8.4	8.0
45		8.1	7.6	8.0	7.9	8.0		8.0	7.9	8.2	8.4	7.9
Bottom	7.9	8.0	7.6	7.6	7.8	7.7		7.4	7.3	7.3	7.2	7.8
					Secchi Disc, feet							
		27	19	17								23

1951
STATION 2 (42° 07.2', 81° 53.9')

Depth in Feet	1951													
	5/23	5/30	6/12	6/21	6/28	7/2	7/12	7/18	7/23	8/2	8/8	8/24	8/28	9/2
						Water Temperature, °C								
Surface	9.1	13.0	15.8	18.5	19.1	19.3	19.9	21.9	21.6	22.3	21.3	21.3	21.8	21.3
30	9.0	11.3		17.1	17.7	18.8	18.9	20.0	21.2	22.1	21.2	21.3	21.5	21.3
45	8.6	8.0		12.4	17.1	8.7	14.7	14.9	16.0	21.2	21.2	21.3	21.4	21.3
Bottom	6.6	7.9		9.2	10.2	8.5	10.4	9.5	11.0	12.7	10.2	10.5	10.8	11.3
Mean	8.6	10.4		14.7	15.9	15.5	16.9	18.1	18.7	20.6	19.8	18.8	20.6	20.6
Mean of Epilimnion				17.1	18.0	19.0	19.3	20.8	21.4	22.1	21.3	21.3	21.6	21.3
						Dissolved Oxygen, ppm								
Surface	10.2	11.9	10.9	10.7	10.8	9.8	9.1	9.2	9.0		8.1	8.6	8.9	
30	11.4	11.6	11.2	10.6	10.2	9.7	9.6	9.5	9.1		8.9	8.8	9.2	
45	12.3	12.4	10.5	10.9	9.2	9.3	9.7	9.0	8.8		8.7	7.8	9.1	
Bottom	11.1	11.3	10.6	10.5	9.2	9.2	9.0	8.7	8.3		7.4	5.6	4.7	
						Free Carbon Dioxide, ppm								
Surface	7.1	6.2	5.4	2.2	3.2	6.2	3.5	0.9	2.6	0.0	0.0	0.0	0.0	
30	5.3		5.4	1.8	1.8	5.3	3.5	2.2	3.5	0.0	0.0	0.0	0.0	
45			5.4	2.6	3.1	5.3	6.1	3.5	3.5		0.0	0.0	0.0	
Bottom			5.4	4.4	3.6	7.1	5.3	4.4	4.4	3.1	4.8	1.8	3.1	
						Methyl Orange Alkalinity, ppm $CaCO_3$								
Surface	100	120	126	107	108	101	104	104	106	104	104	104	102	
30	120		120	107	107	103	104	104	102	103	103	105	105	
45			122	109	110	105	105	106	108		102	105	105	
Bottom			108	109	109	104	105	108	109	105	104	107	108	
						Phenolphthalein Alkalinity, ppm $CaCO_3$								
Surface	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	3.0	5.0	3.5	
30	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0	2.5	3.0	
45			0.0	0.0	0.0	0.0	0.0	0.0	0.0		1.0	2.0	1.5	
Bottom			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
						pH								
Surface	7.8	7.8	7.8	7.7	7.9	7.6	8.0	8.2	8.3	8.0	8.0	8.0	8.3	
30	7.8		7.9	7.8	7.9		7.7	7.9	8.1	8.3	8.0	7.9	8.4	
45			8.0	7.7	7.6		7.7	7.7	8.0		7.9	8.0	8.4	
Bottom	7.8		8.0	7.6	7.5	7.8	7.7	7.5	7.7	7.5	7.6	7.5	7.9	
						Secchi Disc, feet								
	13	11			40		23	29	22				26	

1952
STATION 2 (42° 07.2', 81° 53.9')

Depth in Feet	6/4	6/12	6/17	6/27	7/5	7/14	7/29	8/8	8/19	8/30	9/5
						1952					
					Water Temperature, °C						
Surface	13.7	14.9	18.5	18.7	21.9	23.1	25.2	23.7	24.3	23.1	22.0
30	12.4	13.4	14.2	18.4	20.0	22.1	24.4	23.2	23.5	22.5	21.8
45	8.8	11.4	9.4	14.5	19.7	21.3	24.1	23.0	23.4	21.9	21.6
Bottom	8.7	9.7	9.1	9.8	11.2	11.4	11.2	11.9	11.4	11.5	11.2
Mean	11.3	13.0	13.4	16.4	18.6	21.2	21.2	21.7	21.3	19.4	19.3
Mean of Epilimnion			16.5	19.6	20.3	22.4	24.3	23.3	23.6	22.6	21.8
					Dissolved Oxygen, ppm						
Surface	10.5	9.8	8.8	8.3	9.1	8.6	6.6	8.8	9.0		9.7
30	10.7	10.0	6.4	9.1	9.1	8.5	6.7	8.0	9.2	8.9	9.8
45	10.6	10.0	5.7	8.9	8.7	8.7	7.3	8.3	8.9	8.9	9.6
Bottom	11.0	10.4	5.8	8.6	8.1	8.3	6.9	5.9	8.3	4.7	9.5
					Free Carbon Dioxide, ppm						
Surface	1.3	2.0		0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.3
30	2.0	1.3	0.7	3.3	0.0	2.3	8.6	3.0	0.0	0.0	1.0
45	2.5	1.7	1.7	0.7	0.0	0.0	0.0	0.0	0.0	0.0	1.7
Bottom	1.5	2.3	1.7	1.7	4.0	2.0	1.7	3.3	2.3	0.0	4.0
					Methyl Orange Alkalinity, ppm $CaCO_3$						
Surface	114	106	105	108	97	107	101	97	102	105	81
30	109	112	112	109	102	109	100	97	104	104	95
45	115	114	115	111	104	107	100	104	84	103	94
Bottom	113	112	108	114	110	107	96	107	113	107	89
					Phenolphthalein Alkalinity, ppm $CaCO_3$						
Surface	0.0	0.0	0.0	0.0	6.0	0.0	2.0	3.5	6.5	6.0	0.0
30	0.0	0.0	0.0	0.0	3.5	0.0	0.0	0.0	5.5	11.5	0.0
45	0.0	0.0	0.0	0.0	1.5	4.0	2.0	4.0	10.0	6.5	0.0
Bottom	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	0.0
					pH						
Surface	8.0	8.0	7.4	8.4	8.2	8.0	8.2	8.2	8.3	8.4	7.9
30	8.2	7.9	7.8	8.0	8.1	7.9		7.5	8.4	8.4	8.2
45	7.8	7.9	8.0	7.9	7.9	8.0	7.9	8.4	8.0	8.2	8.4
Bottom	8.0	7.9	7.4	7.9	7.6	7.9	8.0	7.4	8.0	7.8	8.3
					Secchi Disc, feet						
	15	28	48	28	42	28	28		28	25	19

1947 and 1948
STATION 3 (42°01.2', 81°52.8')
STATION 4 (41°56.4', 81°52.8')
STATION 5 (41°51.6', 81°52.8')

Depth in Feet	Station															
	3	4	5	3	4	5	3	4	5	3	4	5	3	4	5	5
	1947						1948									
	8/13	8/13	8/13	9/27	9/27	9/27	4/23	4/23	4/23	6/4	6/4	6/4	7/8	7/8	7/8	8/13
	Water Temperature, °C															
Surface	25.0	25.9	26.7	16.8	18.4	18.6	4.2	4.5	4.6	16.0	16.6	16.4	20.6	20.2	20.0	21.5
30	23.4	23.2	23.7	16.4	18.4	18.4	4.2	4.3	4.3		12.3		19.0		19.3	
45	21.8	20.7	21.5	16.2	17.7	18.0				10.6		12.1	16.9			21.1
60	11.0	10.5	11.3	16.0	11.7	11.0				10.5			10.2	16.4	17.4	11.2
Bottom	10.7	10.5	10.7	14.7	11.0	11.0	4.2	4.2	4.2	10.5	10.7	10.2	9.6	11.3	11.6	10.9
Mean	20.0	20.1	20.8	16.4	17.0	16.8	4.2	4.3	4.3	11.7	12.4	12.1	16.4	17.4	17.8	18.6
Mean of Epilimnion	23.7	23.5	24.0		18.1	18.4							19.5	18.6	19.1	21.3
	Dissolved Oxygen, ppm															
Surface									11.6			8.3	8.9		9.2	8.5
30									9.0				11.6		9.0	
45																8.1
60															6.7	
Bottom									7.6				11.6			3.4
	Free Carbon Dioxide, ppm															
Surface									0.0		0.0	0.0	0.0		0.0	0.0
30												0.0	0.0		0.0	0.0
45											0.0	0.0	0.0		0.0	0.0
60									0.0		0.0		1.3		0.9	1.8
	Methyl Orange Alkalinity, ppm $CaCO_3$															
Surface									100		105	102	96		99	102
30												104	99		100	104
45											103	104	100		99	104
60									100		105	108	108		106	108
Bottom											104	104				104
	Phenolphthalein Alkalinity, ppm $CaCO_3$															
Surface									4.0		5.0	4.0	5.0		4.0	5.0
30												1.6	4.4		7.2	5.0
45											3.0	3.0	6.8		6.0	4.0
60									4.0		1.0		0.0		0.0	0.0
Bottom												3.0				
	pH															
Surface									8.0	8.1	8.1	8.1	8.4		8.4	8.4
30										8.1	8.1	8.1	8.4		8.4	8.4
45										8.1		8.1	8.2		8.4	8.4
60									8.0	8.1	8.1	7.9	7.4		7.6	7.2
Bottom																7.4

1949 and 1950
STATION 3 (42°01.2', 81°52.8')
STATION 4 (41°56.4', 81°52.8')
STATION 5 (41°51.6', 81°52.8')

Depth in Feet	Station											
	3	4	5	3	4	5	3	4	5	3	4	5
	1949						1950					
	8/4	8/4	8/4	8/23	8/23	8/23	6/8	6/8	6/8	7/26	7/26	7/26
Water Temperature, °C												
Surface	24.8	24.3	24.0	23.6	23.8	23.7	17.1	16.3	16.0	20.7	20.7	21.0
30	23.8	23.8	23.8	22.9	23.4	23.1	12.5	12.2	12.7			
45	23.5	23.5	22.4	22.6	23.1	23.0	9.2	9.1	6.4	20.2	20.3	20.3
60	11.5	11.0	11.1	13.2	12.5	12.1	6.4	6.2	6.3	8.8	14.5	9.1
Bottom	11.2	11.0	10.8	12.3	11.8	11.6	6.3	6.2	6.3	8.7	8.6	9.0
Mean	20.1	21.0	19.6	21.3	21.3	20.1	10.9	10.6	10.7	18.0	18.1	17.1
Mean of Epilimnion	23.9	23.8	23.7	23.1	23.4	23.1	13.8	20.4	13.4	20.5	13.6	20.6
Dissolved Oxygen, ppm												
Surface	8.7	8.8	8.7				11.5	9.4	10.5	8.4	9.4	9.7
30	8.8	8.9	8.8				11.6	11.1	11.3	9.4	9.4	9.5
45	8.8	8.7	8.9				11.7	11.3	10.4	9.6	9.6	9.4
60	6.4	6.2	6.9				10.8	11.1	10.1	8.3	8.2	8.3
Bottom	6.2	6.4	6.7				11.4	11.6	10.1	7.9	8.3	7.9
Free Carbon Dioxide, ppm												
Surface	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
30	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
45	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.9	0.0	0.0	0.0
60	5.0	2.0	3.0	1.8	2.6	2.2	1.3	1.3	2.2	1.8	1.8	2.6
Bottom	5.5	4.0	4.0	4.5	4.0	3.5	2.2	1.8	3.5	3.5	2.6	2.6
Methyl Orange Alkalinity, ppm $CaCO_3$												
Surface	116	116	114	116	116	120	100	105	109	109	110	110
30	114	114	114	118	116	116	97		110	109	110	108
45	114	116	114	116	116	118	97	105	108	109	110	108
60	110	112	110	114	114	114	96	107	97	110	108	108
Bottom	108	110	110	116	116	112	102	100	104	110	108	106
Phenolphthalein Alkalinity, ppm $CaCO_3$												
Surface	5.0	5.0	5.0	5.0	5.0	5.0	2.0	2.0	4.0	6.0	6.0	6.0
30	2.0	5.0	4.0	5.0	4.0	4.0	4.0	5.0	3.0	4.0	6.0	6.0
45	2.0	4.0	4.0	4.0	4.0	3.0	0.0	5.0	0.0	4.0	6.0	6.0
60	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bottom	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
pH												
Surface	8.2	8.2	8.2	8.5	8.5	8.5	7.9	8.1	8.1	8.2	8.2	8.2
30	8.2	8.2	8.2	8.5	8.5	8.5	8.0	8.0	8.0	8.2	8.2	8.2
45	8.2	8.2	8.1	8.4	8.5	8.2	7.9	7.6	7.8	8.0	8.2	8.2
60	7.4	7.5	7.5	7.7	7.5	7.8	7.7	7.6	7.6	7.7	7.4	7.5
Bottom	7.3	7.4	7.3	7.4	7.3	7.5	7.7	7.6	7.6	7.4	7.4	7.4
Secchi Disc, feet												
	26	27	25		26	22	26	23				

1951
STATION 3 (42°01.2', 81°52.8')
STATION 4 (41°56.4', 81°52.8')
STATION 5 (41°51.6', 81°52.8')

Depth in Feet	Station														
	3	4	5	3	4	5	3	4	5	3	4	5	3	4	5
	1951														
	5/30	5/30	5/30	6/12	6/12	6/12	6/28	6/28	6/28	7/18	7/18	7/18	8/28	8/28	8/28
Water Temperature, °C															
Surface	11.6	11.7	11.8		15.5	15.8	20.5	20.7	20.2	23.0	23.6	24.2	22.3	24.6	24.1
30	9.7	9.9	10.9		13.7	14.3	17.0	17.5	18.0	21.3	19.4	18.6	21.5	22.1	21.6
45	9.3	9.8	10.8		10.1	10.4	16.5	12.1	12.6	18.5	16.6	16.3	21.4	21.6	21.4
60	6.3	6.4	6.9		6.8	6.8	7.7	7.2	7.2	7.9	8.1	8.0	10.2	20.8	9.6
Bottom	6.3	6.4	6.9		6.8	6.7	7.7	7.1	7.2	7.8	8.0	7.8	10.2	10.2	9.4
Mean	9.3	9.1	9.7		11.2	11.5	14.8	13.7	12.4	16.7	16.0	16.2	19.7	20.4	19.2
Dissolved Oxygen, ppm															
Surface	11.4	11.6	10.7	11.7	11.5	11.0	10.0	9.8	10.0	9.2	9.3	9.1	9.0	9.2	9.1
30	11.3	12.2	10.6	12.2	10.3	10.8	10.5	10.1	9.8	9.5	9.7	9.3	9.0	9.3	8.9
45	12.3	12.6	10.6	12.5	12.3	11.9	10.0	10.5	9.9	9.6	9.7	9.3	9.0	9.0	
60	10.9	12.1	9.6	11.4	11.4	11.9	10.2	10.4	9.5		8.9	8.9	3.2		
Bottom	10.9	11.6	8.0	10.9	11.0	10.1	10.0	10.3	10.0	8.5	8.2	9.6	2.1	4.9	5.0
Free Carbon Dioxide, ppm															
Surface	10.6	10.6	6.2	6.2	4.4	5.3	5.3	3.5	3.5	0.9	3.1	3.1	0.0	0.0	
30					4.4	4.4	5.3	3.5	4.4	2.2	1.3	4.8	0.0	0.0	0.0
45					4.4		5.3	3.5	5.3	3.0	3.1	2.2	0.0	0.0	
60					4.4		3.5	5.3	5.3		4.4	5.7	2.6	2.6	
Bottom			7.0		5.3	7.1	3.5	7.0	5.3	4.4	5.3	4.4	4.4	6.6	0.9
Methyl Orange Alkalinity, ppm $CaCO_3$															
Surface	118	116	120	108	110	108	106	110	110	104	104	102	104	104	
30					104	106	120	106	107	106	104	106	108	104	106
45					108		106	108	110	106	104	103	105	102	
60					112		112	109	110		106	104	105	103	
Bottom			110		110	112	112	109	109	108	108	105	105	104	106
Phenolphthalein Alkalinity, ppm $CaCO_3$															
Surface	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	1.0	
30					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	1.0	3.5
45					0.0		0.0	0.0	0.0	0.0	0.0	0.0	3.0	2.0	
60					0.0		0.0	0.0	0.0		0.0	0.0	0.0	0.0	
Bottom					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
pH															
Surface	7.8	7.8	7.8	8.0	7.9	6.8	7.9	8.2	8.2	8.0	8.0	7.9	8.4	8.0	
30					7.5	7.9	7.7	8.0	7.9	7.8	8.0	7.7	8.3	8.2	8.4
45					7.7		7.6	7.9	7.6	7.5	7.7	7.8	8.3	8.3	
60					7.7		7.7	7.9	7.6		7.3	7.4	7.4		
Bottom			7.7		7.6	7.6	7.6	7.6	7.6	7.3	7.3	7.3	7.4	7.5	7.5
Secchi Disc, feet															
	17	18	18				26	30	30	30	45	37	26	31	32

1950 and 1951
STATION 6 (41° 43.8', 81° 55.8')
STATION 7 (41° 34.8', 82° 04.2')
STATION 8 (41° 27.6', 82° 22.8')
STATION 9 (41° 30.0', 82° 40.8')
STATION 14 (41° 53.4', 82° 24.6')
STATION 15 (41° 58.2', 82° 15.0')
STATION 16 (42° 01.8', 82° 04.2')

Depth in Feet	Station												
	14	15	16	14	15	16	6	7	8	9	14	15	16
	1950										1951		
	6/25	6/25	6/25	7/30	7/30	7/30	7/26	7/26	7/26	7/26	7/23	7/23	7/23
Maximum	45	58	65	38	63	69	66	52	42	28	50	65	65
Water Temperature, °C													
Surface	22.4	21.8	21.8	22.4	22.4	22.4	21.2	20.5	24.7	26.3	24.1	22.4	22.2
30	8.7	18.2	18.5	17.7	20.8	20.9	20.5	19.5	21.3		9.6	20.8	21.2
45	8.5	8.5	16.9		19.7	20.2	19.4	19.1			9.4	18.4	15.2
60			8.8		12.5	8.2	9.1					9.3	9.2
Bottom	8.5	8.2	8.7	14.0	8.4	8.1	9.1	12.2	18.6	20.9	9.3	9.2	9.1
Dissolved Oxygen, ppm													
Surface	9.7		9.3	8.3	8.3	8.4	9.5	9.2	8.2	11.3	9.0	9.2	9.1
30	6.7	9.7	9.8	7.5	8.6	8.7	9.4	8.1	7.9		7.9	9.3	9.1
45	6.3	9.0	9.5		8.1	8.6	9.2				7.8	8.4	8.4
60			8.5		6.1	8.6	8.2					7.8	8.0
Bottom	6.3	9.1		7.5		6.9		4.7	7.6	7.7			
Free Carbon Dioxide, ppm													
Surface	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.7	1.8
30	7.9	0.0	0.0	2.6	0.0	0.0		0.0	0.9		3.6	1.4	2.7
45	13.0	8.8	0.0		0.0	0.0	1.3	0.9			4.5	3.2	3.6
60			16.7		4.4	1.8	1.8					5.4	4.5
Bottom	13.0	16.7		2.6		2.6		2.2	1.8	0.9			
Methyl Orange Alkalinity, ppm $CaCO_3$													
Surface	113	116	112	105	106	104	108	108	108	106	102	104	106
30	115	115	119	107	106	106		109	108		105	104	108
45	125	113	116		105	105	110	111			108	106	106
60			118		107	104	114					106	112
Bottom	125	132		107		100		111	108	108			
Phenolphthalein Alkalinity, ppm $CaCO_3$													
Surface	0.0	2.0	2.0	2.5	2.5	2.5	2.5	2.0	3.0	3.0	0.0	0.0	0.0
30	0.0	1.0	0.0	0.0	2.0	2.0		1.5	0.0		0.0	0.0	0.0
45	0.0	0.0	0.0		2.0	2.0	0.0	0.0			0.0	0.0	0.0
60			0.0		0.0	2.0	0.0					0.0	0.0
Bottom	0.0	0.0		0.0		0.0		0.0	0.0	0.0			
pH													
Surface	8.0	8.2	8.2	8.3	8.4	8.5	8.2	8.2	8.2	8.5	8.3	8.1	8.3
30	7.9	8.2	8.2	7.5	8.2	8.2	8.2	8.2	7.6		7.9	8.2	8.2
45	7.4	7.7	8.2		8.2	8.2	8.0	7.8			7.8	8.2	7.6
60			7.4		7.3	7.5	7.5					7.4	7.6
Bottom	7.4	7.5		7.5		7.4		7.4	7.6	7.8			
Secchi Disc, feet													
	30	7									10	27	30

1950 and 1951
STATION 18 (42° 12.6', 81° 32.4')
STATION 20 (42° 16.8', 81° 10.8')
STATION 22 (42° 27.6', 80° 49.2')
STATION 23 (42° 28.8', 80° 31.8')

Depth in Feet	Station															
	18	20	22	23	18	20	22	23	18	20	22	23	18	20	22	23
	1950								1951							
	7/5	7/5	7/5	7/6	8/8	8/8	8/8	8/11	7/2	7/2	7/2	7/3	8/8	8/8	8/8	8/9
Maximum	73	65	58	48	71	67	60	52	73	70	65	55	73	73	61	50
Water Temperature, °C																
Surface	19.7	20.2	18.6	18.0	22.1	22.5	22.4	21.1	18.8	19.0	19.6	20.8	21.9	21.8	21.2	21.9
30	16.4	16.7	15.4	13.6	20.9	21.2	20.8	18.0	18.5	18.5	19.2	19.5	21.5	21.5	20.5	20.3
45	7.8	16.0	7.3	8.5	20.5	21.0	20.4	15.2	7.7	8.3	8.6	5.9	21.4	21.4	15.8	16.1
60	7.6	8.1			10.7	20.8	13.6		7.6	8.3	8.5		10.9	10.9	11.2	
Bottom	7.4	8.0	7.2	8.3	10.3	14.2	13.6	14.7	7.6	8.3	8.5	5.8	10.8	10.8	11.2	14.7
Dissolved Oxygen, ppm																
Surface	8.2	9.1	8.2	10.0	8.7		9.7	8.4	9.8	9.6	9.5	9.3	8.3	8.8	9.0	9.0
30	8.4	8.6	8.4	9.5	8.3	7.2	9.9	9.0	9.7	9.6	9.5	9.5	8.6	8.8	9.0	
45	8.7	9.0	8.0		8.2	6.5	9.7	8.8	10.7	9.8	9.5	12.1	8.9	8.8	8.0	
60	8.1	9.0			7.3	4.8	8.3		9.5	9.6	9.5		6.2	6.6	7.9	
Bottom	7.5	8.8	8.0	9.8	7.3	4.4	8.3	8.5	9.1	9.0		12.3	6.3	6.3	7.9	8.5
Free Carbon Dioxide, ppm																
Surface	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	3.5	3.5	3.5	8.0	0.9	2.6	0.0
30	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	5.3	4.4	4.4	5.3	0.0	0.0	1.3	0.0
45		0.0	2.6	1.3	0.0	0.0	0.0	0.9	5.3	4.4	4.4	7.0	13.2	0.0	3.5	
60					2.6	0.0	1.8		5.3	6.2	5.3		6.2	3.1	4.0	
Bottom			2.6	1.8	3.5	1.8	1.8	1.3		5.3		7.0	5.3	3.5	4.0	1.3
Methyl Orange Alkalinity, ppm $CaCO_3$																
Surface	100	106	104	105	98	99	104	104	101	104	104	102	104	104	102	106
30	100	110	110	108	98	100	103	105	101	101		104	103	105	103	105
45	105	100	107	105	101	101	101	103	100		102	105	104	105	105	
60	130	100			108	99	100		100	102	103		108	106	106	
Bottom	120	78	103	106	104	105	100	104		102		106	107	106	106	108
Phenolphthalein Alkalinity, ppm $CaCO_3$																
Surface	2.0	2.0	2.5	2.5	2.5	2.0	2.5	2.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	3.0
30	1.0	2.0	0.0	2.0	1.5	1.0	3.0	1.0	0.0	0.0		0.0	2.0	3.0	0.0	3.0
45	0.0	1.0	0.0	0.0	1.5	2.0	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	
60	0.0	0.0			0.0	2.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	
Bottom	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0		0.0	0.0	0.0	0.0	0.0
pH																
Surface	8.1	8.2	8.0	8.2	8.4	8.4	8.4	8.4	7.9	7.9	7.9	7.9	7.9	7.9	8.2	
30	8.0	8.1	8.0	8.0	8.3	8.2	8.4	8.2	8.0	7.8	7.9	8.0		8.2	7.8	8.2
45	7.6	8.0	7.8	7.7	8.2	8.2	8.3	7.8	7.8	7.6	7.7	7.8	7.8	8.0	7.5	
60	7.5	7.6			7.5	8.2	7.6		7.6	7.5	7.6		7.5	7.7	7.4	
Bottom	7.4	7.4	7.8	7.6	7.3	7.4	7.6	7.7		7.4		7.6	7.6	7.7	7.4	8.1
Secchi Disc, feet																
									23	23	21	19				

1950 and 1951
STATION 24 (42°27.6', 79°54.0')
STATION 25 (42°31.8', 80°02.4')

Depth in Feet	Station 24				Depth in Feet	Station 25	
	7/6/50	8/10/50	7/3/51	8/9/51		7/7/50	8/10/50
Maximum	197	180	197	190		112	127
Water Temperature, °C							
Surface	17.9	20.1	20.2	21.1	Surface	17.8	20.8
30	13.8	20.1	17.4	20.9	30	13.0	18.4
60	7.8	14.5	5.2	10.2	45	10.6	15.5
90	5.7	6.1	4.2	6.9	60	9.7	11.3
120	4.3	4.0	4.0	5.5	75	8.2	6.5
150	4.0	4.0	4.0	4.6	90	4.2	4.4
Bottom	3.9	4.0	4.0	4.4	Bottom	4.0	4.1
Dissolved Oxygen, ppm							
Surface		8.8	9.2	8.9	Surface	8.1	9.0
30	9.4		9.5	9.0	30	8.7	9.2
60	9.2		12.3	9.0	45	8.7	9.0
90	8.2		12.6	9.9	60	8.3	9.6
120	9.1		12.8	11.4	75	8.0	9.3
150	9.1	8.2	12.0	11.3	90	9.0	9.5
Bottom	8.2		11.2	10.0	Bottom	8.0	8.7
Free Carbon Dioxide, ppm							
Surface	0.0	0.0	5.3	0.0	Surface	0.0	0.0
30	0.0		7.0	0.0	30	1.3	0.0
60	1.8		7.0	2.6	45	1.3	0.4
90	1.3		5.3	1.7	60	1.3	1.8
120	2.6		6.1	1.3	75	2.2	1.8
150	2.6	1.8	5.3	0.9	90	3.1	1.8
Bottom	2.2		5.3	1.3	Bottom	2.6	2.6
Methyl Orange Alkalinity, ppm $CaCO_3$							
Surface	110	104	104	106	Surface	112	102
30	108		104	106	30	110	100
60	106		104	106	45	119	102
90	104		103	106	60	110	101
120	110		103	106	75	113	105
150	111	105	106	105	90	112	105
Bottom	106		109	106	Bottom	114	110
Phenolphthalein Alkalinity, ppm $CaCO_3$							
Surface	2.0	1.5	0.0	4.0	Surface	3.0	2.5
30	1.0		0.0	3.0	30	0.0	2.0
60	0.0		0.0	0.0	45	0.0	0.0
90	0.0		0.0	0.0	60	0.0	0.0
120	0.0		0.0	0.0	75	0.0	0.0
150	0.0	0.0	0.0	0.0	90	0.0	0.0
Bottom	0.0		0.0	0.0	Bottom	0.0	0.0
pH							
Surface	8.2	8.2	8.0	8.2	Surface	8.2	8.4
30	8.1		7.8	8.2	30	7.9	8.3
60	7.7		7.6	7.9	45	7.9	7.9
90	7.6		7.7	8.1	60	7.8	7.6
120	7.8		7.6	8.0	75	7.8	7.5
150	7.8	7.5	7.5	7.9	90	7.7	7.5
Bottom	7.6		7.5	7.9	Bottom	7.7	7.4